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THE TECHNOLOGY REVIEW

A NATIONAL JOURNAL DEVOTED TO SCIENCE, ENGINEERING, AND THE PRACTICAL ARTS

Edited at the Massachusetts Institute of Technology

VOLUME XXXIV NUMBER 4

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PUBLISHED monthly on the twenty-seventh of the month preceding the date of issue at 50 cents a copy. Annual subscription $3.50; Canadian and foreign subscription $4.00. Published for the Alumni Association of the Massachusetts Institute of Technology. Bradley Dewey, President; George K. Burgess, Donald G. Robbins, W. Malcolm Corse, Vice-Presidents; Charles E. Locke, Secretary.

Published at the Rumford Press, 10 Ferry Street, Concord, N. H. Editorial Office, Room 11–203, Massachusetts Institute of Technology, Cambridge A, Mass. Entered as Second-Class Mail Matter at the Post Office at Concord, N. H. *Copyright, 1932, by the Alumni Association of the Massachusetts Institute of Technology.* *Three weeks must be allowed to effect changes of address. Both old and new addresses should be given.*

From a pencil and crayon drawing by Leopold de Postels of the de Postels Studio

AT THE behest of a traveling public insatiable for speed, spectacular size, and voluptuous luxury, the shipbuilding industry is strenuously planning ships that are a little longer, a bit swifter, and more elaborately comfortable. In the article on page 165, this course of events is analyzed, and in the tables on pages 166 and 167 an inventory of the world's great passenger vessels, built or planned, is presented

THE
TECHNOLOGY
REVIEW

Vol. 34, No. 4 January, 1932

THE HUMAN POWER PLANT

Peak Capacity of American Hearts over Half a Million H. P.

By V. Bush and W. D. Reid

Editorial Note. This article contains an announcement of a new and marvelously sensitive electrocardiograph for studying the action of the heart. The device is the result of joint research carried on by the Evans Memorial Hospital, Boston, and the Electrical Engineering Department of M. I. T.

HUMAN hearts of the United States develop normally a combined output of about 70,000 horse power, an amount approximately equivalent to that necessary on the average for light and power in a city the size of Boston. They have, moreover, a very large overload capacity, and can produce in a pinch about eight times normal output for a short interval. The installed peak internal pumping capacity of the population is hence over a half-million horse power. This pump delivers some 130 billion gallons of blood a day which is about 40 times the total flow of water used for all domestic purposes throughout the country, nearly equivalent to the flow of the Niagara River, or enough to fill the largest reservoir of the world behind the Hoover Dam in two months' time. The aggregate size of this pumping plant is therefore considerable, but its size is completely overshadowed by its reliability.

Most hearts proceed throughout a complete lifetime without servicing, completing a total of 2,000 million fairly complex complete operations without overhaul or major failure. An automobile engine, after an extreme life of 50,000 miles of operation, completes only 200 million revolutions, or 10% of the complete operations of a heart; and it very seldom does this much without overhaul.

About one heart in six actually fails in service. This ratio would be significantly decreased if hearts were given the periodic attention habitually lavished by many on fine motors, and if the accumulated knowledge of cardiac experts were utilized freely by those whose hearts were shown by diagnosis to have need of service. It is not considered good form to operate a fine car with leaky valves. Those of the heart cannot be taken out and ground, it is true, but many an incipient leak can, nevertheless, be rectified.

The heart is not only a pump, it is also a generator of electricity. Like other muscle tissues its operation is accompanied, in a way which is still in its detail mysterious, by the production of differences of electrical potential. That the actuating mechanism of a muscle is susceptible to electrical stimulation became convincingly apparent when, about 1770, Galvani first made a frog's legs twitch by connecting crude electric cells between a nerve and muscle. It had, in fact, been illustrated much earlier by the violent contraction of the muscle of the first victim to pick up inadvertently a charged Leyden jar. Similarly, it has long been known that natural muscular contractions are accompanied by changes in electrical potentials, and as early as 1855, Kolliken and Müller demonstrated that this was true of the heart muscle of a frog.

As an electrical generator, however, the human heart is not a powerful apparatus. The electric eel, *electrophorus electricus*, can generate in some very clever way enough electrical energy to stun a large antagonist, and this in spite of the fact that he

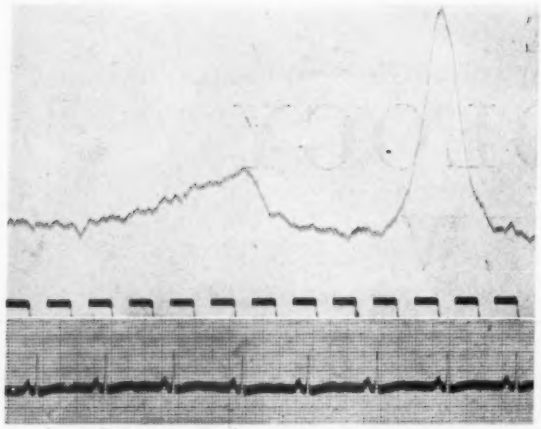


Figure 1

appears to be continuously short circuited by the medium in which he lives. Compared to this eel, man is a weak generator indeed. Accompanying heart action, there appears at electrodes placed far apart on a human body a difference of potential which has a value when averaged against the total time of about one-quarter of a millivolt. The body resistance varies widely, but a representative value is about 2,500 ohms. Hence the maximum of the mean electrical power output into an external circuit from this source of potential difference can be only about six micromicrowatts, or, in the terms previously used, about one one-hundred-million-millionth of a horse power. If applied for lighting purposes this amount of power would be capable of giving a one-second illumination of a small flash light bulb once in a thousand years. This is not a large amount, yet the accurate measurement of the time variation of this potential difference furnishes one of the accepted means of investigating the performance of the heart. This is the subject of electrocardiography.

In 1887 Waller made use of the capillary electrometer on man, and in 1892 Bayliss and Starling obtained the first good records which could truly be called electrocardiograms. The capillary electrometer, which has now been largely forgotten by experimenters, consists of a column of mercury in a capillary tube on top of which is sulphuric acid, and it depends for its action upon the fact that the surface tension in the interface is considerably changed when the interface is polarized. The fact that this instrument was successfully used to record the rapid variations in the weak potential difference accompanying heart action, crude though the results were bound to be in terms of present-day technique, excites intense admiration when one properly evaluates the work in terms of the experimental situation of the time.

In 1903 Einthoven of Leyden introduced his string galvanometer, and the use of this greatly simplified the problem and rendered possible rapid advance. This instrument consists essentially of a very fine wire stretched in a powerful constant magnetic field. Very minute currents through the wire cause it to deflect appreciably, and optical arrangements make possible a time record of the movements. A typical record obtained in this manner is shown at the bottom of Fig. 1. For nearly 30 years and until quite recently this has been the only working tool for both clinical and research electrocardiography. It has accomplished much, and by its use has been built up an invaluable record of experience, so that this form of the electrocardiograph has certainly made it possible for the modern physician to understand numerous cardiac conditions and often to apply effective treatment to sick human beings in a way that was quite impossible to physicians of a few decades ago. String galvanometer studies have gone far to determine what drugs are really valuable and what are ineffective or worse. The instruments are used in many of the larger hospitals and clinics throughout the world and much significant knowledge has been obtained by careful correlation of electrocardiographic findings in life with conditions disclosed at post-mortem examinations. Yet the string galvanometer has very serious limitations, and the art of measuring minute electrical magnitudes has proceeded far since Einthoven's work in 1903.

THE advent of the thermionic tube really revolutionized the technique of fine electrical measurement. Concurrently with its widespread use in radio and telephony it has had a less spectacular application in all sorts of investigatory work in the laboratory. This is primarily due to two outstanding characteristics which render it uniquely applicable to the measurement of rapidly varying or very weak phenomena. The first of these is its almost complete lack of inertia, the only time-lag present being due to the small time it takes for an electron to pass over the short distance from the filament to the plate. Thus, as an oscillator, it can readily be made to repeat a predetermined performance 100 million times per second. The second characteristic is the fact that a significant power output from its plate circuit can be accurately and completely controlled by an extremely small input to its grid. How small this can be is not always realized. A tube recently produced by the General Electric Company, and designed to have a very low grid current, can operate with an input current of 10^{-17} ampere. Several analogies have been given to aid in visualizing this magnitude, in comparison with the full ampere taken by an incandescent lamp of moderate size, but, if it is permissible to add to these, the following analogy seems to have been overlooked. If the single ampere in the lamp be represented by all the women of this country talking in unison at the rate of 150 words per minute, then the grid

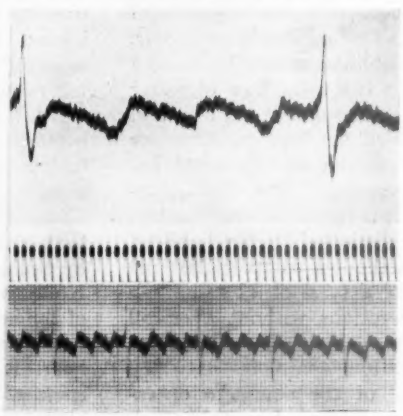


Figure 2

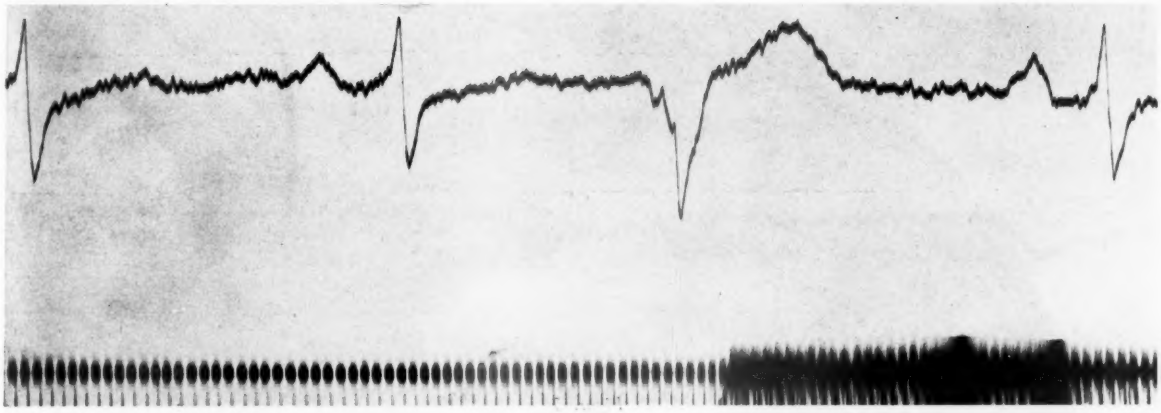


Figure 3

current of the tube is represented by a lone mountaineer in the Smoky Mountains who enunciates one monosyllable in 30 years.

It is inevitable that the thermionic tube amplifier should be applied to cardiography and to analogous problems of the physician, the physiologist, and the biologist. Much has, in fact, been accomplished, and work such as that of Adrian * on the electrical potential differences appearing in nerves, and of Osterhout † on the electrical phenomena occurring in a single cell of Nitella (a fresh-water plant with cells six inches in length) is notable. Several electrocardiographs, utilizing thermionic tube amplifiers in conjunction with oscillographs have also appeared. In many of these, quite properly in view of the clinical records available in this form, the attempt has been to duplicate the results given by the string galvanometer rather than to improve upon them, and to provide added convenience and portability. It is evident, however, that there is an opportunity to overcome some of the string galvanometer's limitations as well. With this object in view a coöperative research has been conducted in which the Evans Memorial has worked closely with the Department of Electrical Engineering of the Massachusetts Institute of Technology. This has resulted in the production of an instrument, which, in its present form, is decidedly a research tool rather than a clinical instrument.‡ It is not intended that such an instrument should immediately supersede the string galvanometer, for to fail to use to the utmost the experience which has been obtained with that instrument would be unfortunate. Rather, it is hoped that instruments of the new type may be extensively developed to supplement the work of the galvanometer and produce additional results, a new set of facts, and a body of experience which with the old instrument and its limitations was unattainable and the existence of some of which was hardly suspected.

The new instrument has primarily accomplished three things as compared to the old. First, by extending the range of frequencies which can be readily recorded, it has brought out detail which was lost or barely discernible in the older records. Second, by drawing a negligible current for its operation it has avoided errors due to the flow of significant current through the

* Adrian, E. D.: "The Impulse Produced by Sensory Nerve Endings," *Jour. Physiol.* 61:49, 1926.

† Osterhout, W. J. V.: *Electrical Phenomena in the Living Cell*, Harvey Lectures, Series 25, Williams and Wilkins Company, Baltimore, 1931, p. 169.

‡ Reid, W. D.: "Preliminary Report on the Use of an Improved Form of Electrocardiograph," *Jour. Lab. and Clin. Medicine*, in press. Caldwell, S. H. ['25], Oler, C. B. ['31], and Peters, J. C. Jr. ['30]; "An Improved Form of Electrocardiograph," soon to be published.

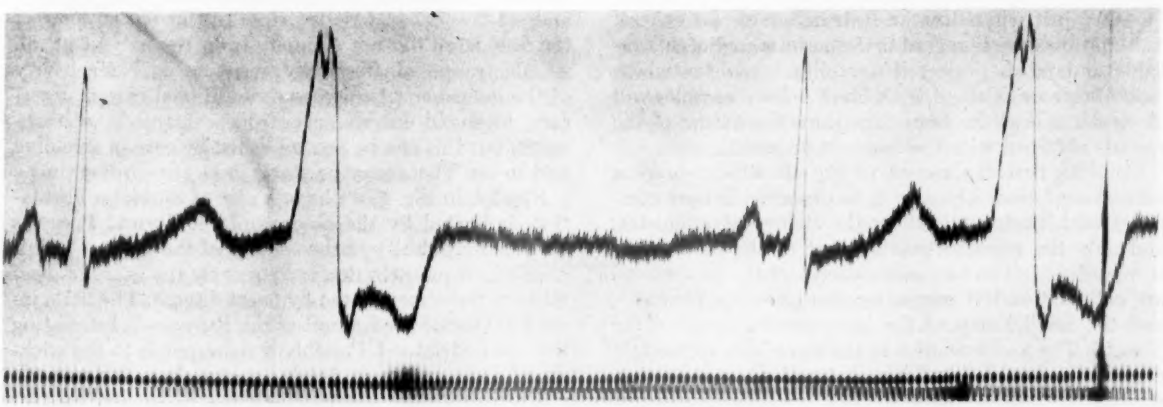


Figure 4

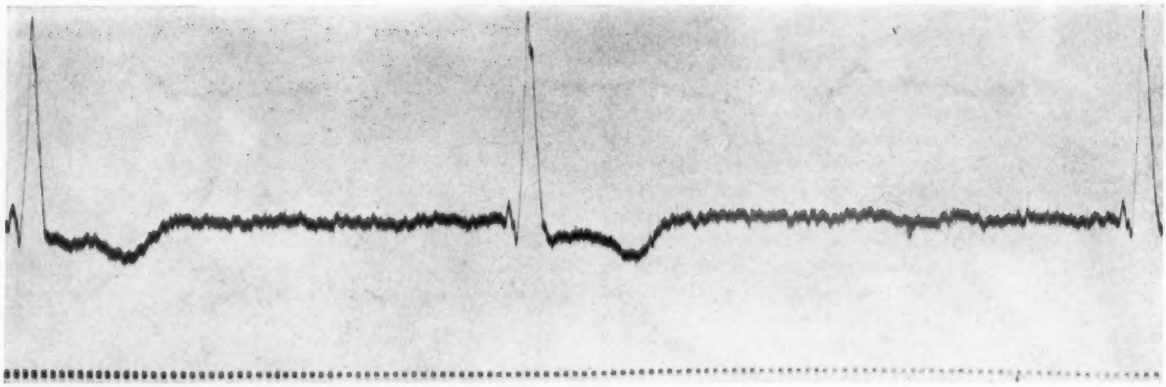


Figure 5

variable impedance of the skin layer. Third, it has produced an enlarged record with a relatively fine line. Its use gives the sensation that now one can study under high power, of the microscope as it were, what formerly could be viewed only under low power.

It will doubtless take considerable time plus the examination of many patients and careful correlation of the new records with the findings on living patients and at post-mortem examinations to determine what new information of value will be obtained by use of the improved form of electrocardiograph, but it requires little enthusiasm to feel that the use of this instrument will throw further light upon conditions pertaining to the heart and circulatory system. Later on, instruments of this sort, which can readily be designed to have many features of convenience, may well take the place of the older type. While conservatism among the medical profession in regard to a change of this sort is entirely laudatory for the reason given, a major change in technique once in a generation is hardly to be termed radical. With the advance which has occurred in the art of measurement, and with the present situation in which almost identical apparatus to that employed in this investigation is being utilized for the measurement of weak electrical potential differences for all sorts of purposes in large numbers of scientific laboratories, an ultimate change in this direction appears inevitable.

NOW just what does an instrument of this general nature show in regard to the performance of that reliable and much neglected pumping apparatus which each of us carries about with him? A few examples will illustrate, and at the same time show the nature of the records obtained with the newer instrument.

Consider first the record of Fig. 1, which shows a normal condition. The new type of record is here compared with that obtained by the string galvanometer, and only the more interesting part of the new record is reproduced. The two main humps of the new record are called P and R waves for identification purposes, and the small hump of the lower record is called the T wave. The minor wiggles in the record are apparently due to incidental muscular contractions, rather than directly to cardiac action; they are enormously increased in size and may even obscure the desired record if the patient is tense. The little irregularities on the side hill of the R wave may, however, be of much significance, as they are repeated with considerable faithfulness in the records of successive beats. Since they are indistinguisable in the older records they have not as yet been much studied. Here the heart is firing regularly on all four cylinders, the valve setting is normal, the valves are tight, and the ignition system is functioning smoothly. Many years from now this particular heart will probably be still going through its complicated performance accurately and reliably, much to the satisfaction of its owner.

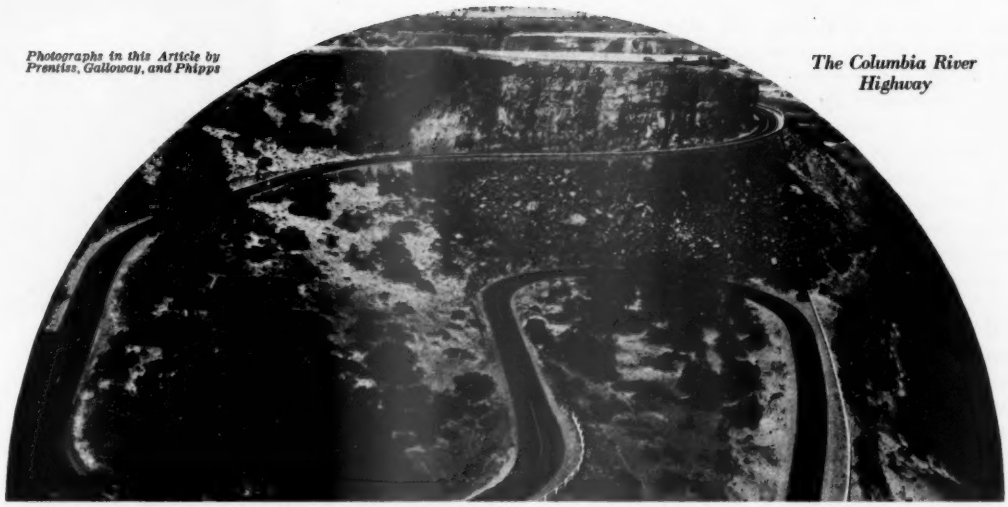
Now consider Fig. 2. In this heart the ignition system is decidedly out of adjustment and one cylinder is being fired several times per cycle. This is a case of auricular flutter. Part of the heart, the auricles, is in a state of constant activity. It would be difficult to conceive of a man-made motor which would continue to function under similar conditions of maladjustment.

Fig. 3 shows normal rhythm interrupted by extrasystoles, one being shown by the inverted wave not preceded by a P wave. This machine is missing. Strange to tell, it is apparently a harmless condition, and does not call even for new spark plugs or adjustment of the distributor. Backfires into the carburetor do not appear to be cause for alarm with the heart.

Fig. 4 presents another case of extrasystoles, shown here by the wide bifurcated wave. This heart appears to have something akin to explosions in the muffler, and yet it is not in serious shape. In this record some of the fine detail did not emanate from the patient at all. As the range of frequency response and sensitivity of the instrument is increased, additional care is necessary to avoid interference from extraneous disturbances, but this can be accomplished by care in shielding and so on. There may be static in electrocardiograms.

Finally, in Fig. 5, we have a case of auricular fibrillation, indicated by the absence of the normal P waves and the irregularity of the spacing of the R waves. This form of irregular rhythm is frequently the cause of disability in patients affected by heart disease. The little indentation near the summit of the R waves is interesting but not understood. Possibly it corresponds to the sticking of a valve stem, and then again perhaps it does not.

The instrument now available is a reasonable tool for electrocardiographic research, (*Concluded on page 188*)



Photographs in this Article by Prentiss, Galloway, and Phipps

The Columbia River Highway

THE FUTURE OF ENGINEERING

Its Significance as a Social Force

By Karl T. Compton

INTELLIGENT interpretation of the observed course of events in the past is the only valid method of predicting the course of events in the future. I should like to follow this method to investigate from several aspects the probable place in society which the engineer will hold in the near future.

In the past, the great developments in civilization have taken place under conditions in which there was a sufficient productive power to give the necessary leisure for education and constructive thought. In the ancient civilizations of the Egyptians, the Greeks, and the Romans, this productive power was obtained through the use of slaves captured in war. By their efforts their conquerors were freed from the necessity of continually struggling to acquire means of sustenance, and were able to devote their time to art, to the construction of great monuments, to the initial investigations in science, and to the establishment of systems of law and government.

Again in the period of the Renaissance, the great advances in civilization were made by the leisure class and the members of the religious organizations, both of whom were supported by the efforts of their fellow men who tilled the soil or wove the cloth.

The tremendous advances of our own civilization during the past 50 or 100 years are due more than anything else to the harnessing of the power of steam and the utilization of the energy in coal and water power. The socially important aspect of the machine age is not the machines themselves or the great structures which have been built, but is to be found in the fact that the tremendously increased productive power brought into being by machinery has released human thought and energy for development in directions other than mere existence.

The time which has been freed by increased productive power is now devoted in youth to education. It is this which has made possible the universal system of education which is adopted in this country and which has made possible college and postgraduate training of a large portion of our youth. Thus, while the productive power *per se* is unimportant, the opportunities for education and cultural development which are made possible through increased productive power are perhaps the most important benefits inherent in our present civilization.

Because of increased productive power, it is no longer necessary to devote all of our efforts to the production of the bare necessities of food and shelter. An increasing portion of our effort goes into things which, for a time, are called luxuries, but which very quickly come to be looked upon almost as necessities. These are such things as modern household equipment, modern methods of communication and transportation, newspapers, books, radios, and the like.

Every one of these things adds to comfort, to interest in life, and to opportunities for self-expression. These things, furthermore, present constantly new lines of interest and objectives for study and development. Thus the mental as well as the physical life is benefited.

Still another by-product of productive power is the opportunity which has been created for studies

in health and sanitation. These studies have had the remarkable result of increasing the average span of human life from 33 years to 60 years within the last 140 years. When it is realized that untimely death is frequently accompanied by unusual suffering, it takes little imagination to visualize the great benefit which has come with the development of medical science.

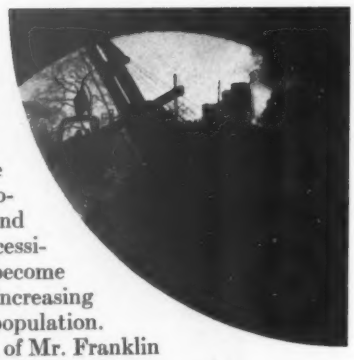
It is increased productive power which makes possible such benefits as insurance, old-age pensions, disability and retiring allowances, unemployment insurance, and all of those similar means for relieving anxiety and suffering in times of disability and old age.

THERE are some people who wonder whether the increased efficiency of production through labor-saving devices and more effective methods may not be responsible for the present state of overproduction, unemployment, and, in short, the economic ills of the present year. Now, what actually are the facts, and what would happen if the acceleration of production were reduced?

During the 30 years, from 1899 to 1929, while the population of the United States has increased from 75 to 121 million, the percentage of the population gainfully employed has remained constant at 39%, the percentage employed in factories has increased from 6% to 7%, and factory wages have increased 300%. The annual value of factory products has increased from 11 billion to 68 billion dollars, of which the part which was added in the process of manufacture has increased from five billion to 31 billion dollars. Of this increased value, the factory worker has received quite uniformly throughout the past 30 years a constant fraction amounting to about 40%.

The significance of these figures may be stated briefly as follows. The introduction of labor-saving devices has not thrown workers out of employment, because the statistics show that the proportion of the population engaged in such work has in reality increased. What has actually happened is that just as fast as a labor-saving device enables one workman to do the work which formerly required three, his wages have increased to the total amount formerly paid to the three, and the other two workmen, thrown out of employment in that industry, have found other higher-salaried employment in new industries which have in the meantime been created by scientific and engineering development. The figures show no tendency for the workers to receive a smaller proportion of the financial benefits introduced by more efficient means of manufacture during the past 30 years. The workers receiving 40% of these benefits, the remaining 60% is chargeable to development costs and to profit by the stockholders, which profits in turn are rapidly turned over into the development of still newer industries,

and into supporting the demand for additional products. In this way, the luxuries of yesterday, such as the telephone, the automobile, the automatic refrigerator, and so on, become the necessities of today, and become available to an ever-increasing proportion of the population.



To quote the words of Mr. Franklin Hobbs: "The machine age has increased employment, increased wages, made work easier, saved lives and limbs, and enabled the working man to live in such comfort and luxury as was unknown to any man on earth when some of us were born.

"Had there been no time-saving and labor-saving tools introduced into factories during these last 30 years, there could have been no electrical appliances, no telephone, no automobile, no moving pictures, no radio, no airplane, and the lowly cigarette which you smoke today would be beyond the reach of a man of ordinary means."

This is not to say that there are no isolated regions and temporary periods in which the balance of production and employment may be upset by the introduction of new devices and methods, but the figures show conclusively that on the average the result of such things has been beneficial.

THE social sciences as well as the natural sciences have an important rôle to play in bringing about more satisfactory conditions of living. I believe it to be demonstrable, however, that it is the natural and physical sciences which create the opportunities for what we call the higher things of life and which are really the basis of great advances in economic and social welfare. Mr. Kettering of the General Motors Company has recently called attention graphically to the difference in the mode of attack by the social scientists and the engineers in handling a common economic problem. He pictures a population of 100 million, of whom five million are unemployed. What measures to alleviate this situation can be taken by the two groups of scientists? The social scientists may devise a scheme for unemployment insurance, doles, restricted and distributed hours of labor, or taxes, which will serve to alleviate the suffering of the unemployed. The engineer, on the other hand, creates the automobile, or the sanitary system of water supply, or the telephone, which prove to be so desirable to the remaining 95 million that the five million unemployed are set to work manufacturing these new products.

In discussing our future outlook in a recent article in *Scribner's Magazine*, the internationally known historian of Columbia University, Professor James T. Shotwell, makes this significant statement: ". . . but, whatever theory one may adopt as to the ultimate outcome, *the pathway to the future is in the hands of the engineer*, not of the economist, (*Concluded on page 185*)

LUXURY AFLOAT

Will the Faster and Larger Ocean Liners Earn Their Keep?

By H. H. W. Keith and H. E. Lobdell

SPEED, size, and luxury are hall marks of the great liners which lately have been launched or planned as additions to the world's merchant marine. Two are being built which are to exceed in speed and size any passenger vessel now afloat. Others built or building embody notable advances in safety, in noise and heat insulation, in the sanitary conditions surrounding the preparation of food, and in ventilation and air-conditioning.

But it is in contrivances listed as luxury features with which the newer ships abound. Baths galore (salt, fresh, Turkish, and steam), telephones (intramural and ship-to-shore), elevators and peacock alleys, garages, swimming pools (indoor and outdoor), Ritz bars, gymnasia, brokers' offices and children's playrooms, night clubs, chapels, veranda cafés, sport decks and talkie theaters, penthouse and period suites, beauty salons and apparel shops, staterooms with private piazzas, and sand beaches for sun bathing — all are proudly cataloged to lure jaded travelers to forsake the older ships for the new. Nearly every conceivable gadget which modern hotel-keeping has devised to tempt the ultra-Sybarite has a nautical counterpart, though diligent search of marine literature and steamship company blurbs fails to uncover public admission that any owner has yet dared the egregious stunt of piping radio willy-nilly to every stateroom.

The tables on the succeeding two pages list the present prospective passenger-carrying vessels of over 13,000 gross tons in size which are capable of 20 knots sea speed, or approximately 23 land miles per hour. There are twice as many ships of this class now afloat as were in service 10 or 20 years ago. Additions during 1932 and next year will more than make up for any retirements.

No longer is it axiomatic that the leading passenger ships which ply on the "Atlantic Ferry" between Europe and the United States outrank in size and speed those on other oceans. As an examination of the tables will show, such a magnificent vessel as *L'Atlantique* upholds the traditions of the service maintained under the French flag for over 60 years from Europe to Brazil and the River Plate. It compares most favorably with the *Empress of Britain*, newest flagship of the Canadian Pacific's fleet, or the *Ile de France*, *Aquitania*, *Olympic*, or even the *Europa* and *Bremen*. The time and tedium of a voyage from Europe or America to Australia, or from the United States or Canada to the Orient, have been diminished by ships of a type which before the War would have been foreordained for North Atlantic lanes.

Two superliners, projected for the Cunard and French lines, have tonnages nearly half again as large as any previous merchant ship. As the first to exceed 1,000 feet in length, they will, if ever completed, fulfill a vision with which naval architects have been preoccupied since the War. The *Baltic* of 1904, famed as the first to exceed a length of 700 feet, was followed after an interval of about seven years by the *Olympic*, which was the first to exceed 800 feet, but only two ships, the *Majestic* and the *Leviathan*, have exceeded 900 feet in length.

Both of these superliners, as well as the *Super-Leviathan* (a near-1,000-footer, still on paper and perhaps destined to remain in that state indefinitely) are planned to have sea speeds of 30 knots plus, nearly 35 land miles per hour. This means that they are aimed at duplicating in regular services the record run at 30.66 knots made between San Pedro and Honolulu in 1928 by the U. S. S. *Lexington*. The Cunarder is to employ single-reduction geared turbines of an unstated horse power; the French ship is to become the largest turbo-electric merchantman and is designed for upwards of 160,000 S.H.P.; for the *Super-Leviathan* one proposal is for geared turbines with a maximum of 180,000 S.H.P. and the other for turbo-electric drive with a maximum of 200,000 S.H.P. The *Lexington* and *Saratoga*, now the most powerful ships afloat, have turbo-electric drives and are rated at 180,000 S.H.P. The *Bremen* lists at 132,000, the *Conte di Savoia* at 120,000, the *Mauretania* at 68,000, the *Empress of Britain* at 64,000, and the *Manhattan* at 34,500.

THE problems of superliners are not so much those of marine engineering as of economics. On the "Atlantic Ferry," to which their use will be restricted, they may be expected to make approximately 19 round-trip voyages a year, assuming that their normal schedule will be about 28 knots, except during the peak load of summer, when traffic may make it feasible to step them up to a weekly one-way trip schedule, operating at about 30 knots. Figures as to their capital investment are meager, but it has been stated that the interior fittings and equipment of the Cunarder are to cost about 15 millions, or approximately the total cost of the *Empress of Britain*, and more than the total costs of the *Manhattan* (about 10¼ millions), the *President Hoover* and *Mariposa* (around eight millions apiece). In lean months especially, the inherent operating expense of the superliners will be burdensome for, roughly speaking, fuel consumption varies as the cube of the speed, and operation at high speeds is accompained by excessive wear and tear on machinery, not to mention the enormous operating overhead and port charges.

Even in the somewhat smaller vessels, such as the Italian *Rex* and *Conte di Savoia*, the German *Europa* and *Bremen* (four ships comparable in tonnage to the aging *ex-Vaterland* and her two sisters), the financial return on the investment is necessarily low. The economics of large liners was summarized some years ago by Carl E. Peterson in a paper presented before the Society of Naval Architects (*Concluded on page 184*)

The World's Merchant Fleet

Vessels capable of 20 knots or better and over 13,000 gross tons

Listed in the Order of Their Gross Tonnage

Now in Service

Name and Line	Gross Tonnage	Length x Beam (feet)	Sea Speed (knots)	Built	See Footnote*	Flag	Service **
1. *Majestic* (ex *Bismarck*), White Star	56,621	915 x 100	25	1921	oil T4	Br.	NoAt
[Gross tonnage quoted according to rules adopted by British lines. If measured according to United States rules, *Majestic's* gross tonnage would be 61,206 and *Leviathan's* (up to two months ago), 59,956. *Leviathan*, however, has recently been remeasured and, largely by the reclassification of certain spaces within the superstructures, her former American rating figure dropped from 59,956 to 48,590.]							
2. *Leviathan* (ex *Vaterland*), U. S.	54,282	907 x 100	24	1914	oil T4	U. S.	NoAt
3. *Berengaria* (ex *Imperator*), Cunard	52,226	883 x 98	23½	1912	oil T4	Br.	NoAt
4. *Bremen*, No. Ger. Lloyd	51,656	898 x 100	26	1929	oil T4	Ger.	NoAt
[Bremen holds transatlantic speed record of 4 days, 14 hours, 30 minutes, between Cherbourg Breakwater and Ambrose Channel Lightship, averaging 27.83 knots. *Europa* on one crossing averaged 27.91 knots between these points but, because of variations in her course, took 4 days, 17 hours, 6 minutes, and thus missed the record.]							
5. *Europa*, No. Ger. Lloyd	49,746	890 x 102	26	1930	oil T4	Ger.	NoAt
6. *Olympic*, White Star	46,439	852 x 92	22½	1911	oil T3	Br.	NoAt
[*Olympic* and her sister, *Titanic*, were the first vessels to exceed 800 feet in length. *Olympic's* passengers on October 27, 1914, witnessed the sinking of H. M. S. *Audacious*, first British capital ship loss of the War, after she struck a mine while carrying out firing practice off Lough Swilly.]							
7. *Aquitania*, Cunard	45,647	868 x 97	23½	1914	oil T4	Br.	NoAt
[Holds world record for "turn round" for large liner: 14½ hrs. at Southampton, October 21, 1931.]							
8. *Île de France*, French	43,153	763 x 92	22	1926	oil T4	Fr.	NoAt
9. *Empress of Britain*, C. P. R.	42,328	758 x 98	24	1931	oil T4	Br.	NoAt
[Flagship of C. P. R. fleet. Largest vessel plying between British ports. Docked June 22, 1931, at Quebec from Southampton and Cherbourg with average for voyage of 26.22 knots. Has largest swimming pool and only really complete Turkish bath afloat. Passenger capacity, 1,195.]							
10. *L'Atlantique*, Sud Atlantique	40,945	733 x 92	21	1931	oil T4	Fr.	SoAt
[Largest vessel plying between Europe and South America. All first-class cabins open on a central avenue in lieu of usual longitudinal galleries separated by funnel casings; a "rue" or street with shops, 460 feet long; first-class dining saloon 115 ft. by 66 ft. Passenger capacity, 1,232.]							
11. *Paris*, French	34,569	735 x 85	22	1921	oil T4	Fr.	NoAt
12. *Homeric*, White Star	34,351	751 x 83	20	1922	oil 2	Br.	NoAt
[Largest twin screw vessel afloat.]							
13. *Augustus*, Nav. Gen. Italiana	32,650	666 x 82	20	1927	m. s. 4	It.	NoAt
[World's largest and fastest motorship and the only motorship with cruising speed equal to 20 knots. White Star's *Britannic* (26,943 tons) and her sister, the *Georgic*, launched at the Belfast Yards of Harland & Wolff, Ltd., on November 12, 1931, are the next motorships in size to the *Augustus*. They possess the highest powered individual sets of diesel propulsion machinery in marine service but have a sea speed of only 17 knots. Cosulich's *Vulcania* (23,970 tons) and *Saturnia* (23,940 tons) are fourth and fifth in size among motorships. Each has a sea speed of 19 knots.]							
14. *Roma*, Nav. Gen. Italiana	32,583	705 x 82	21	1926	oil T4	It.	NoAt
15. *Columbus*, No. Ger. Lloyd	32,354	749 x 83	20	1922	oil 2	Ger.	NoAt

Building or Projected

Name and Line	Gross Tonnage (est.)	Length x Beam (feet)	Sea Speed (knots)	See Footnote*	Flag	Service **
No. 534, Cunard	73,000	1018 x 115	30+	oil T4	Br.	NoAt
[Launching was to take place February, 1932, at Clydebank Yards, John Brown & Co., Ltd., but, on December 10, 1931, Cunard announced the suspension of all work on *No. 534*. Will be world's largest marine geared turbine installation.]						
Super-Île de France, French	70,000	1017 x 115	30	oil T4	Fr.	NoAt
[Expected launching September, 1932, at Penhoët Yards, St. Nazaire. Will be the world's largest turbo-electric ship except for U. S. S. *Saratoga* and *Lexington*. Dining saloon 164 ft. by 115 ft. One galley with single electric range serves 2,000 passenger capacity. In tonnage this ship exceeds combined tonnages of 152 ships in Spanish Armada and the 79 ships of the opposing English fleet. Penhoët Yards also cradled the *France*, *Paris*, *Île de France*, *L'Atlantique*.]						
Super-Leviathan, U. S.	59,000	970 x 108	30+	oil T4	U. S.	NoAt
[Preliminary plans ready. Keel laying depends on Congress. Passenger capacity, 2,800.]						
Rex, Nav. Gen. Italiana	50,000	880 x 101	27	oil T4	It.	NoAt
[Launched Sestri Levante, August 1, 1931. Passenger capacity, 2,250.]						
Conte di Savoia, Lloyd Sabaudo	48,000	812 x 96	27+	oil T4	It.	NoAt
[Launched San Marco Yard of Cantieri dell' Adriatico, Trieste, October 28, 1931. Passenger capacity, 1,900. Geared turbines. Has 3-unit million dollar Sperry gyroscope stabilizing plant. Each unit's rotor is 13 feet in diameter and weighs 100 tons. Has 18 watertight compartments and 58 watertight cells in ship's double bottom. Will have largest electrical equipment afloat.]						

16. *Mauretania*, Cunard	30,696	762 x 88	25½	1907	oil T4	Br.	NoAt
[Held Atlantic Blue Riband 22 years and when 20 years old proved herself capable of steaming at 29 knots to the rescue of a disabled cargo ship. Her sister, the *Lusitania*, was torpedoed and sunk by the German submarine, *U-20*, on May 7, 1915, off Old Head of Kinsale with a loss of 1,198, a marine disaster exceeded only by the loss of 1,517 when White Star's *Titanic* sank after collision with an iceberg in the North Atlantic on April 15, 1912.]							
17. *Cap Arcona*, Hamburg-Sud-Amerika	27,561	643 x 84	20	1927	oil T2	Ger.	SoAt
[Second largest vessel plying between Europe and South America.]							
18. *Conte Grande*, Lloyd Sabaudo	25,661	652 x 78	21	1928	oil T2	It.	NoAt
19. *Empress of Japan*, C. P. R.	25,000	666 x 87	21	1930	oil T2	Br.	NoPac
[Largest vessel plying in transpacific service.]							
20. *Conte Biancamano*, Lloyd Sabaudo	24,416	650 x 76	21	1925	oil T2	It.	NoAt
21. *Duilio*, Nav. Gen. Italiana	24,281	602 x 76	21	1923	oil T4	It.	SoAt
22. *France*, French	23,769	690 x 75	24	1912	coal T4	Fr.	NoAt
23. *Strathnaver*, P. & O.	22,547	664 x 80	22	1931	oil T2	Br.	LoAus
[Largest vessel in London-Bombay-Australia service. Passenger capacity, 1,168.]							
24. *President Hoover*, Dollar	21,936	654 x 81	21	1931	oil T2	U. S.	NoPac
[Largest vessel, except for *Empress of Japan*, in transpacific service. Passenger capacity, 988. Period suites with private veranda. Garage, "drive your own car off and on at every port, if you wish."]							
25. *President Coolidge*, Dollar	21,936	654 x 81	21	1931	oil T2	U. S.	NoPac
[Sister of *President Hoover*. These two ships are the largest American-built turbo-electric vessels, exceeding Panama Pacific's *California*, *Pennsylvania* and *Virginia* by nearly 1,400 tons and at least 3 knots; and being nearly twice the tonnages, though about the same speed, as Ward Line's *Morro Castle* and *Oriente* which maintain 60-hour N. Y.–Havana service.]							
26. *Giulio Cesare*, Nav. Gen. Italiana	21,657	602 x 76	20½	1921	coal T4	It.	SoAt
27. *Empress of Canada*, C. P. R.	21,517	627 x 77	20	1922	oil T2	Br.	NoPac
28. *Monarch of Bermuda*, Furness-Bermuda	20,500	580 x 77	20	1931	oil T4	Br.	NYBer
[Only passenger liner afloat providing private bath with every stateroom, even in second class. First to have "penthouse" suites. Two night clubs, three veranda cafés. Turbo-electric. Passenger capacity, 830.]							
29. *Otranto*,	20,032	632 x 75	20	1925			
30. *Oronsay*, Orient	20,001	633 x 75	20	1925			
31. *Orontes*, Steam	19,970	638 x 75	20	1929	oil T2	Br.	LoAus
32. *Orford*, Navigation	19,941	632 x 75	20	1928			
33. *Orama*,	19,777	632 x 75	20	1924			
34. *Conte Verde*, Lloyd Sabaudo	18,765	570 x 74	20	1923	oil T2	It.	SoAt
35. *Mariposa*, Matson	18,017	632 x 79	20½	1932	oil T2	U. S.	CalAus
[Air-conditioned dining saloon. Staterooms with private "lanai," or lounging decks. Passenger capacity, 706. Has 16 watertight compartments. Passenger spaces at ship's sides heavily insulated with compressed cork. Electrically equipped from cooking to cargo handling. Dynamo capacity sufficient for a city of 25,000 inhabitants. In trial speed runs December 10, 1931, on Rockland Course off New England coast *Mariposa* made maximum speed 22.843 knots and a mean of 22.274 knots.]							
36. *Malolo*, Matson	17,232	554 x 83	21	1927	oil T2	U. S.	NoPac
37. *Conte Rosso*, Lloyd Sabaudo	17,048	570 x 74	20	1922	oil T2	It.	SoAt
38. *Empress of Asia*, C. P. R.	16,909	570 x 68	20	1913	coal T4	Br.	NoPac
39. *Empress of Russia*, C. P. R.	16,810	570 x 68	20	1913	coal T4	Br.	NoPac
40. *Massilia*, Sud Atlantique	15,363	577 x 64	20	1920	coal T4	Fr.	SoAt
41. *Lutetia*, Sud Atlantique	14,783	578 x 64	20	1913	coal T4	Fr.	SoAt
[Her sister, the *Gallia*, was torpedoed and sunk in the War.]							

Manhattan, U. S. — 30,000 — 705 x 86 — 21 — oil T2 — U. S. — NoAt
[Launched Camden Yards, N. Y. Shipbuilding Company, December 5, 1931. Geared turbines. Largest merchant marine ship ever built in U. S. and first built in U. S. for transatlantic service since the 11,629-ton, 21-knot *St. Louis* and her sister, the *St. Paul*, of 1897. Passenger capacity, 1,320. Features: ventilation; air-conditioning, safety with 11 watertight bulkheads.]

Not Named, U. S. — 30,000 — 705 x 86 — 21 — oil T2 — U. S. — NoAt
[Sister of *Manhattan*. Suggested names, *Martini* and *Bronx*. Keel laid at Camden, March, 1931.]

Champlain, French — 28,000 — 641 x 83 — 20 — oil T2 — Fr. — NoAt
[Launched St. Nazaire, August 15, 1931. Geared turbines. Passenger capacity, 1,092. Expected maiden voyage May, 1932.]

Strathaird, P. & O. — Sister of *Strathnaver*
[Launched Barrow-on-Furness Yards, Vickers, Ltd., July 18, 1931. Due in service February, 1932. These two are largest and fastest British-built turbo-electric vessels, exceeding P. & O.'s *Viceroy of India* by 4,000 tons and at least 4 knots.]

Monterey, *Lurline* — Matson — sisters of *Mariposa* — *Monterey* launched October 10, 1931; *Lurline* keel laid August, 1931 — At Quincy Yards of Bethlehem Shipbuilding Corp.

BY WAY OF COMPARISON

Ten Years Ago: There were 16 merchant vessels afloat capable of 20 knots or better and over 13,000 gross tons. Two were fitted for liquid fuel. The 16, in order of size; were: *Majestic*, *Leviathan*, *Berengaria*, *Olympic*, *Aquitania*, *Paris*, *Mauretania*, *France*, *Agamemnon* (19,361), *Empress of France* (18,481) (still in service but now rated at 19 knots), *Mount Vernon* (18,372), *Empress of Asia*, *Empress of Russia*, *Massilia*, *Von Steuben* (14,901), *Lutetia*.

Twenty Years Ago: There were 16 merchant vessels afloat capable of 20 knots or better and over 13,000 gross tons. Two were fitted for liquid fuel. The 16, in order of size, were: *Olympic*, *Titanic* (45,000), *Mauretania*, *Lusitania* (31,000), *France*, *Kronprinzessin Cecile* (19,503), *Kaiser Wilhelm II* (19,360), *Oceanic* (17,274), *Kronprinz Wilhelm* (14,908), *Kaiser Wilhelm der Grosse* (14,349), *Empress of Britain* (built in 1906, 14,189 tons, or about a third the size of the present vessel bearing this name), *Empress of Ireland* (14,191), *La Provence* (13,753), *Shinyo Maru* (13,500), *Tenyo Maru* (13,454), *Chiyo Maru* (13,426). *Shinyo Maru* and *Tenyo Maru* were still in service in 1931 but were then rated as 16-knot ships.

Thirty Years Ago: There were 5 merchant vessels afloat (or building) capable of 20 knots or better and over 13,000 gross tons. The largest was the *Kaiser Wilhelm II* and the remaining four, in order of size, were: *Oceanic*, *Deutschland* (16,502), *Kronprinz Wilhelm*, *Kaiser Wilhelm der Grosse*.

* "Oil" indicates fitted for liquid fuel; "m. s.," motorship; "coal," uses coal for fuel; "T," turbines; "2," twin screws; "3," triple screws; "4," quadruple screws.

** "NoAt" indicates North Atlantic, European to U. S. and Canadian ports; "SoAt," South Atlantic, European to South American ports; "NoPac," North Pacific, Canadian and U. S. to Hawaiian, Asiatic and/or Philippine ports; "LoAus," London to Australian ports; "NYBer," New York to Bermuda; "CalAus," Californian to Australian ports.

Industrial Disequilibrium

The True Cause of Business Depressions

By Ralph E. Freeman

THE recent revival of astrology under the influence of radio broadcasting furnishes another interesting example of the fact that popular fallacies die hard. In spite of the spread of scientific information and the popularizing of science in modern literature, many people still cling to the belief that the destiny of the individual human being is profoundly influenced by the appearance and arrangement of the stars. A similar persistence is noticeable in regard to economic fallacies. Notwithstanding the expenditure of large sums of money for the teaching of social sciences in our schools and colleges, economic doctrines remain alive which have for many years been condemned by the practically unanimous voice of leading economic authorities. This latter type of fallacy is the more dangerous. The present craze for horoscopes is not likely to undermine the morals of the community or to offer serious hindrance to the advancement of science; but adherence to discredited economic theories may place formidable obstacles in the way of social progress. So long as large numbers of people, among them political and industrial leaders, continue to accept erroneous or superficial explanations for our industrial ills, the proper remedies for these ills will be exceedingly difficult or impossible of application.

There is, for example, the widely held opinion that the existing depression is due to a general overproduction of goods, when the truth of the matter is that the appalling surpluses keeping prices low and men out of work are effects rather than causes. Glutted markets and the accumulation of large stocks of commodities almost invariably appear after the business crisis, and not before. Statistics confirm this view. Mr. Carl Snyder's paper, read before the 1931 meeting of the American Economic Association, disclosed the rather astonishing fact that during the years immediately preceding the crisis of 1929, the output of basic goods was actually smaller than in previous years when no depression occurred. Now, if the source of industrial dislocation lies in the output of too many goods of all kinds, the obvious remedy is to cut down output, or to increase the purchasing power of the consuming public in conformity with the increase of productive capacity. But since the diagnosis is wrong, the remedy will be ineffective. We waste our energies searching for ways and means to remove the consequences of disease rather than its causes. Economic physicians tell us that the world is suffering, not from over-eating, but from an unbalanced diet, and that, if we prescribe for the former ailment, we may starve the patient.

Perhaps the situation can be explained more clearly by the use of a mechanical analogy. Our industrial system is like an airplane which works with greatest efficiency when kept in a state of equilibrium. The latter is held steady under the combined forces of its weight, the power of its engine, and the resistance of the air. While these forces retain their relative values the machine will maintain its progress in horizontal line; but as soon as any one of them changes, the equilibrium is affected and the machine will rise or fall. Though the effect of such changes may be counteracted by balancing devices to promote lateral and longitudinal stability, the principle remains the same; equilibrium is realized when the speed due to motive power is sufficient for the thrust exerted by gaseous molecules gliding under the surfaces of the plane to hold it steady in the air. Should there be a stoppage of the motor or an impairment of the carrying surfaces, the machine would be compelled to come down and its efficiency as an aerial vehicle would be interrupted. Our economic system is in perfect equilibrium when the right amount of each commodity is being produced. The production of one article creates a demand for others. When the furniture industry expands, its manual workers, salesmen, directing officers, shareholders, and the rest who participate in the monetary returns from the sale of furniture are enabled to buy more things than before. This evokes the production of more automobiles, food, clothing, and other commodities. What is true of furniture is also true of hardware,

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confectionery, gasoline, cosmetics, boots and shoes, and so forth; expansion in one line of business creates a demand for expansion in other lines. But this demand will not be exerted with an even pressure throughout the whole system. The stimulus arising from an increase in the textile industry, for example, will not be felt with equal force in all the others. It depends upon how the men and women in the textile industry choose to spend their incomes. If they prefer radios to new clothes, or books to theater tickets, the radio and printing industries will experience a greater urge to expansion than the clothing or theater industries. Each branch of production, whether of goods or services, must develop an appropriate response to the expressed desires of consumers. Only by this means can the equilibrium of the industrial system be maintained.

Of course, some part of the income created by the growth of the textile business would be saved, either as reinvested earnings by corporations or by individuals in the form of investments and bank accounts. These funds would be devoted to the purchase of industrial materials and equipment or loaned to business concerns for maintenance or expansion purposes. If the savings of society were not devoted to uses of this nature, our productive apparatus would soon run down and the habit of saving would be discouraged by the decline and disappearance of interest. Therefore, the stimulus resulting from the expansion of an industry is certain to be felt not only by the producers of goods for immediate consumption, but also by the makers of machinery and the other necessary aids to production. The various branches of the equipment industry will be influenced according to the demand for this or that type of machine, while farmers, miners, and others engaged in the production of raw materials will be induced to expand their operations in answer to the needs of other industries for their particular products. A balance must be maintained between consumers' and producers' goods and between the various types of producers' goods. As soon as we begin to devote too large a proportion of our resources to the production of one article, we disturb the equilibrium of the system.

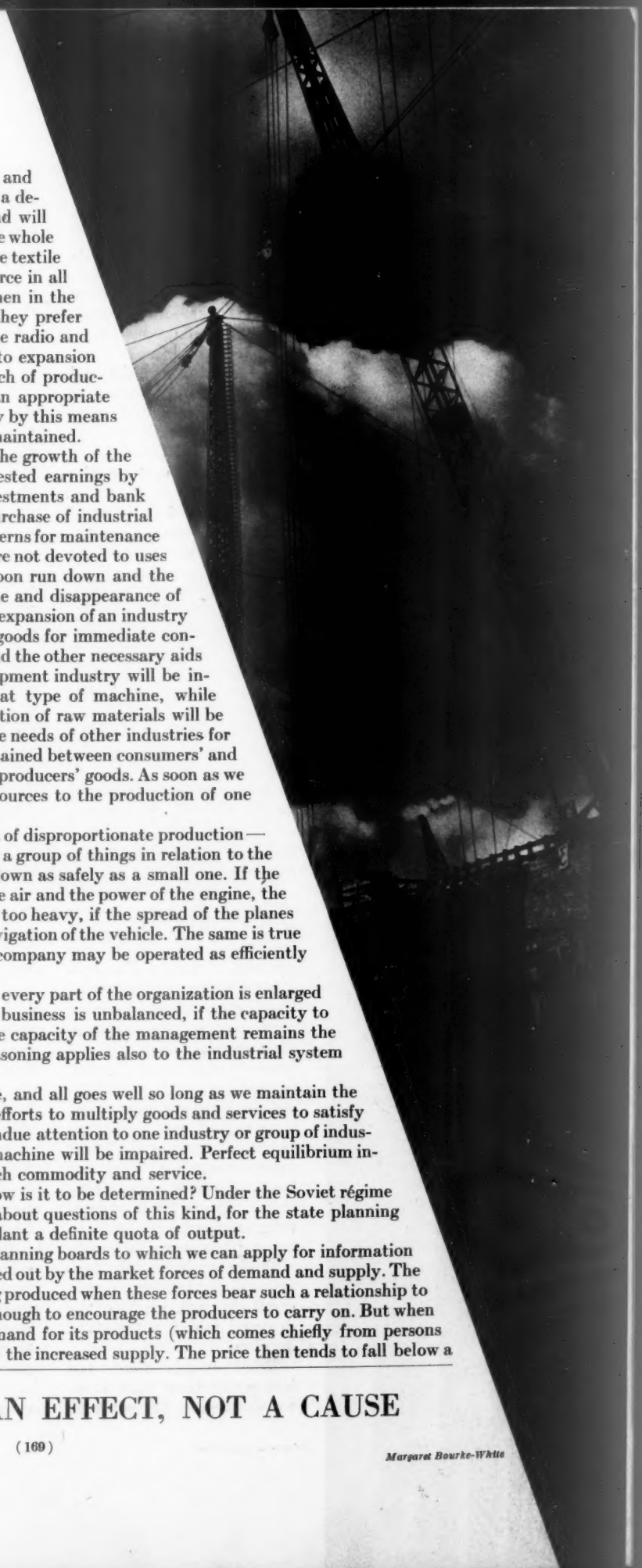
It is not a question of general overproduction, but of disproportionate production—not too much of everything, but too much of one or a group of things in relation to the amounts of the others. A large airplane may be flown as safely as a small one. If the weight is right in proportion to the resistance of the air and the power of the engine, the machine will be stable. But if the engine or cargo is too heavy, if the spread of the planes is insufficient, there is likely to be trouble in the navigation of the vehicle. The same is true of an individual business concern; a billion dollar company may be operated as efficiently as one of relatively meager assets.

Expansion is not likely to be dangerous provided every part of the organization is enlarged in the right proportion; but if the growth of the business is unbalanced, if the capacity to turn out goods, for example, is increased while the capacity of the management remains the same, the result may be disastrous. The same reasoning applies also to the industrial system as a whole.

We strive to make it more and more productive, and all goes well so long as we maintain the proper balance of its various parts. But if, in our efforts to multiply goods and services to satisfy the ever-increasing wants of mankind, we give undue attention to one industry or group of industries, the efficiency of our great want-satisfying machine will be impaired. Perfect equilibrium involves the production of the right amount of each commodity and service.

What is the "right" amount in each case and how is it to be determined? Under the Soviet régime the managers of business do not have to worry about questions of this kind, for the state planning authorities assign to each industry and to each plant a definite quota of output.

But under our competitive system there are no planning boards to which we can apply for information of this character; the control of production is carried out by the market forces of demand and supply. The "right" amount of a particular commodity is being produced when these forces bear such a relationship to each other that a price emerges which is just high enough to encourage the producers to carry on. But when one industry expands disproportionately, the demand for its products (which comes chiefly from persons engaged in other industries) fails to keep pace with the increased supply. The price then tends to fall below a



OVERPRODUCTION AN EFFECT, NOT A CAUSE

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profitable level and production will be curtailed. In this way, the overexpansion which caused the trouble will be corrected. The readjustment may, in some instances, be effected before serious damage is done. And, in similar fashion, if production in one line of business lags behind that of others, demand will outrun supply, bringing an increased price and larger profits, which will eventually stimulate the laggard industry and restore the equilibrium.

If market forces acted freely and promptly, no disturbance of the equilibrium would be more than trivial and temporary. But, unfortunately, this does not always happen. Our economic system is so constituted that maladjustments of supply and demand are constantly throwing it out of balance, and, if we are to find an explanation for the reactions and counter-reactions which have been shaking the world for the last century or more, we must examine those features of the system which promote instability.

One of the most important of them is the pervasiveness of the machine. Mechanical inventions have made our productive methods roundabout and have introduced a longer time interval between production and consumption. Because the production of most things begins many months before they are purchased by consumers, decisions regarding the quantity to be produced must be based upon estimates of what the demand will be. These estimates, no matter how carefully prepared, are certain to be wrong in many instances, with the result that the supply is either too large or too small in relation to the demand which ultimately develops.

What people want and how much they want is always changing. The outbreak of a war, unexpected weather, whims of fashion, the introduction of substitutes — any one of a score of unforeseen events may suddenly alter the character of demand. Moreover, since the volume of output depends upon anticipation of demand, it will be affected by anything that influences the producer's attitude toward the future; and, because the psychological character of the crowd imposes itself upon the individual with extraordinary force and rapidity, a general opinion that trade is declining or improving will mar the estimates of the most hard-headed of business men.

Failure to anticipate demand correctly is often due to the fact that it is subject to stimulating influences of a temporary character. The extension since the war of the practice of buying goods on partial payment plans has greatly enlarged the consumer's capacity to buy. But installment buying as a source of increased purchasing power is bound to fail sooner or later. As soon as a man has spent his income in advance for the next year or two, the best he can do thereafter is to maintain his existing level of expenditure. Unless his income rises, he can no longer buy at an increasing rate. If it should happen that many consumers reach this saturation point at the same or nearly the same time, the sudden falling off in demand would be a serious blow to the manufacturers of furniture, automobiles, radios, and other durable goods of this kind. Then, if in addition to this, the confidence of the community in the maintenance of prosperity should be shaken, consumers, instead of continuing to buy on time, would cut down their purchases and turn to paying their debts. This would make matters still worse.

Another source of temporary demand is to be found in the expansion of bank credit. When the general price level is rising, or (as has happened since the War) production costs are falling, the prospect of increased profits induces business men to borrow more freely from the banks. This credit becomes the basis of augmented purchasing power and may lead to higher prices both of goods and of securities. If the commodity prices rise, speculators buy to hold for an increase in price and business men are willing to purchase and store freely because of the profits to be made out of increases in the value of inventory. If security prices rise and a stock market boom develops, the demand for goods will be further enhanced by the prodigality of successful speculators. The result is a tremendous expansion of business and many concerns begin to build additional plant and add to their productive capacity. But these causes of demand stimulation are transitory. When they disappear, certain industries, especially those engaged in making luxury articles and equipment, find themselves badly out of balance with the rest of the economic world.

But the preservation of a perfect equilibrium involves something more than a correct analysis of the market; it requires also a prompt reaction on the part of producers to changes in the character and extent of the market. Here again we fall far short of perfection. The economic machine does not operate without delay and friction. Our productive resources do not move with sufficient rapidity from one industry to another in response to changes in demand. (*Continued on page 186*)

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THE TREND OF AFFAIRS

IN THIS SECTION: Making Trains Comfortably Cool in the Summer Time (174); *Taking Photographs in the Dark* (175); *A Flying Laboratory* (176); *A Machine to Do the Menial Mental Work of Science and Engineering* (171); *Penetrating the Depths of the Sea* (172); *The Longest Concrete Arch* (173).

Brain Servant

SINCE WATT contrived his wheezy steam engine and Faraday showed how to put electricity to work, man has progressed remarkably in the transfer of physical labor to machines. The next profoundly important advance in the mechanization process, and one that was suggested by Leibniz more than 200 years ago, is the relegation to machines of those mental processes which are inherently mechanical, repetitive, and time-consuming. Such a statement sounds fantastic until one recalls the extent to which mechanical computation has already revolutionized business accounting methods.

But most business computations are simple and elementary and by no means represent the possible achievements of machine thinking. The scientist, the engineer, and the statistician are seeking means to the mechanical solution of equations more complex than profound, which require onerous computation and a waste of valuable time. In short, they, too, need brain servants to do the menial part of thinking.

M. I. T. Photo

A brain servant to do the menial part of engineering thinking: the differential analyzer described adjacently

At M.I.T. a program has been mapped for supplying labor-saving, analyzing devices. Two machines, the product integraph and the photoelectric integraph, have been built and made available for use. And now a third, the most complicated and ingenious of all, the differential analyzer, is announced. The first of these machines, the forerunner of the last, has been used for solving second order, differential equations. The second gives an approach to the integral equation and to certain processes of statistical analysis. The differential analyzer, which has been called one of the most intricate machines ever built, also deals with the differential equation, for which it provides solutions in the form of plotted curves for specified, boundary conditions. It is being used for the solution of these equations of any order up to the sixth and of any amount of complexity within reason.

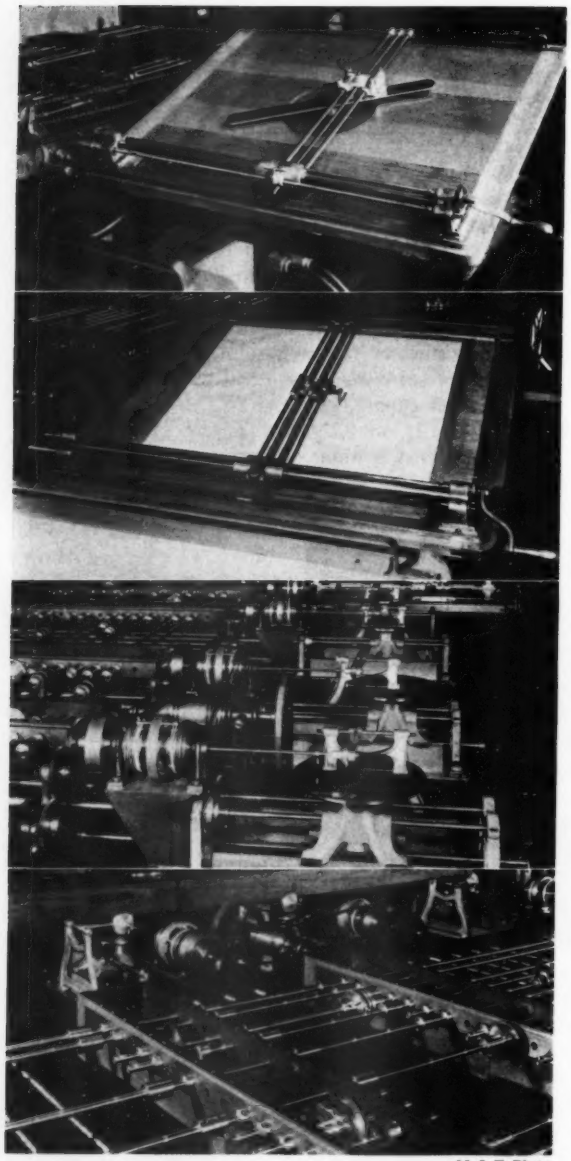
Professor Vannevar Bush, '16, who developed the analyzer, states that it is readily possible when plates have been made and a schematic diagram giving schedules and connections prepared, to set up the machine for a given problem in a few hours. "The time necessary for solutions varies with the complexity of the problem and the precision desired and in representative cases is about ten minutes for each solution corresponding to a given set of boundary conditions. Experience is necessary, of course, in order to use the device effectively. This is actually one of the most attractive aspects of the machine; one acquires an entirely new appreciation of the innate nature of a differential equation as that experience is gained." Aside from its mechanical gifts, the differential analyzer is a triumph of machine design. Methods have been incorporated for eliminating backlash, particularly a device called a "frontlash" unit.

It will be noted from the adjacent photograph that there are provided 18 longitudinal or bus shafts and that these can be readily uncoupled at many points. Along the sides of the device are arranged the main units, the integrators, input tables, multipliers, and output table, each connected to cross shafts.

The analyzer incorporates the basic idea of an interconnection of integrating units and one of its notable features is the addition of mechanical torque multipliers, which render the integrating units capable of carrying a considerable load. Large size has been preserved in order to obtain accuracy of plotting of the variable coefficients and of the result. Various auxiliary units such as multipliers have been provided. A precision of one part in three or four thousand has been arrived at with the intention of achieving a somewhat less overall precision. Except in extraordinary circumstances, all main operations are mechanical with electrical devices used only for drives and controls.

The differential analyzer so far represents man's greatest achievement in building machines to aid him to do the servant work of thinking. Professor Bush, who has supervised the development of all three machines here at the Institute, envisions still other and more versatile machines.

The status of physics and engineering at the present time, Dr. Bush has pointed out, is peculiarly favorable to developments of this sort. "Electrical engineering, for example, having dealt with substan-



M. I. T. Photos

From top to bottom: 1. A multiplier of the differential analyzer. 2. An input table. 3. An integrator connected with a torque amplifier. 4. Longitudinal shafts and frontlash units.

tially linear networks throughout the greater part of its history, is now rapidly introducing into these networks elements, the non-linearity of which is their salient feature, and is baffled by the mathematics thus presented and requiring solution. . . .

"Not any one machine, nor even any one program of development can meet these needs. It was a long, hard road from the adding machine of Pascal to the perforated card accounting machines of the present day. There must be much of labor and many struggles before the full ideal of Leibniz can be consummated."*

*"The Differential Analyzer. A New Machine for Solving Differential Equations." The *Journal* of the Franklin Institute, Vol. 212, No. 4, Oct. 1931.

Down Below

SUBMARINE disasters and the age-old lure of sunken treasure have hastened the development of deep-sea diving apparatus within recent years. The old-fashioned diving suit of fabric and rubber, adequate, if not wholly efficient at depths of less than 50 feet, is of comparatively little use and even dangerous below 100 feet.

Diving operations have increased with the progress of engineering in the construction of bridges, dams, and harbor works, but the conventional diving suit in most instances met all requirements in this work. To the marine engineer, the admiralty expert, and the salvage engineer, facing the inexorable demands of disaster, must go the chief credit for recent progress in diving operations at great depths.

The loss of the United States submarines *S-51* and *S-4* off the Atlantic coast a few years ago not only showed the need for new safety devices for escape from sunken vessels, but focused public as well as professional attention on the serious need for more efficient diving apparatus. Both vessels lay more than 100 feet below the surface.

Man's desire to penetrate the depths of the sea is not new. Divers are said to have been employed to clear underwater barriers erected to damage Grecian ships at the siege of Syracuse, and history relates that Alexander the Great ordered divers to destroy undersea defenses of the besieged at Tyre.

Among the early devices for diving was a crude form of the diving bell under which men worked for brief periods until the enclosed supply of air was exhausted. Later came the simple tube, one end of which the diver held in his mouth while the other end was supported above the surface by an inflated bladder. Alexander the Great himself is said to have once descended into the sea in a device called a Colimpha, the form of which is not known.

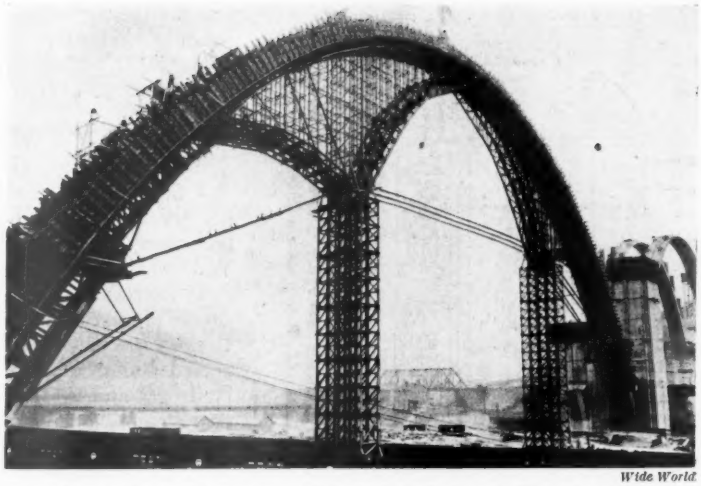
Roger Bacon is reported to have invented a diving bell in 1250, but there is no authentic evidence to indicate the nature of the device. In 1715 John Lethbridge, an Englishman, developed a leather diving suit which held "half a hogshead" of air, which was sufficient for brief underwater operations. The inventor is said to have made a fortune from the device.

Augustus Siebe might well be called the father of modern diving, the genius of submarine tailoring. In 1819 he invented an open diving suit, fitted with a metal helmet and supplied with air under pressure, which kept out water as long as the diver remained upright. The principle was the same as that by which the diving bell operates. Later he improved his suit by closing it entirely and providing an air supply by hose to the helmet. An exhaust valve permitted it to escape. The present-day, conventional diving suit is but an improved model of Siebe's second design.

In order to penetrate the great depths where the pressure is high, the diver who uses the conventional suit of fabric and rubber must be subjected to an air pressure equal to that of water in which he works. It is in this high air pressure within the diving suit that one of the great hazards of undersea operations lies.

Whatever the air pressure is within the suit, it is transmitted to the body of the wearer, being distributed to the tissues and blood vessels, which become saturated with nitrogen. This is due to the fact that a gas in contact with a liquid on which has it no chemical action is absorbed by that liquid.

The fact that the diver's body becomes saturated with nitrogen has no ill effect until he begins to ascend. The reaction then is exactly the same as when a cap is removed from a bottle of carbonated water and gas bubbles to the surface. The nitrogen bubbles in the blood stream and, unless the diver is raised very slowly, this process becomes so rapid that it causes great pain in the muscles and joints, and produces what is known to the diving profession as "bends." In extreme cases it causes death. For this reason divers must ascend very slowly, and for their welfare modern diving operations require that they be placed in decompression chambers as soon as they reach the surface. In these chambers divers are slowly accustomed to normal atmospheric pressure.



Wide World

Building the George Westinghouse bridge in East Pittsburgh. The new bridge consists of five reinforced concrete arches, the central arch having a span of 460 feet — the longest concrete arch yet built in the United States

Thus it will be seen that diving under high air pressures makes operations both slow and hazardous. The ideal for a diving suit, then, is a device in which the diver may be supplied with air at normal pressure, regardless of the depth at which he works. Several armored diving suits designed to withstand the pressures in deep water have already been developed and successfully used. Another improvement in more recent diving apparatus of this type is a self-contained supply of air carried in tanks attached to the suit. This innovation does away with the necessity of supplying air through a hose from the tender-ship, and makes it much easier for the diver to move about on the bed of the sea. In devices of this type the only connections between the diver and his ship are a light lifeline, telephone, and electric light cables.

A few years ago Professor Elihu Thomson, Life Member of the Institute's Corporation, suggested that helium gas be used in the place of nitrogen in the atmosphere supplied to divers in deep-water operations. Helium has a solubility in water nearly 40% less than nitrogen, and in exposure to compressed air nearly 40% less gas will be dissolved in the watery parts of the body. Helium also will escape from the lungs much more quickly than nitrogen during the decompression period and thus the diver may ascend faster. Experiments with the mixture suggested by Dr. Thomson have proved successful.

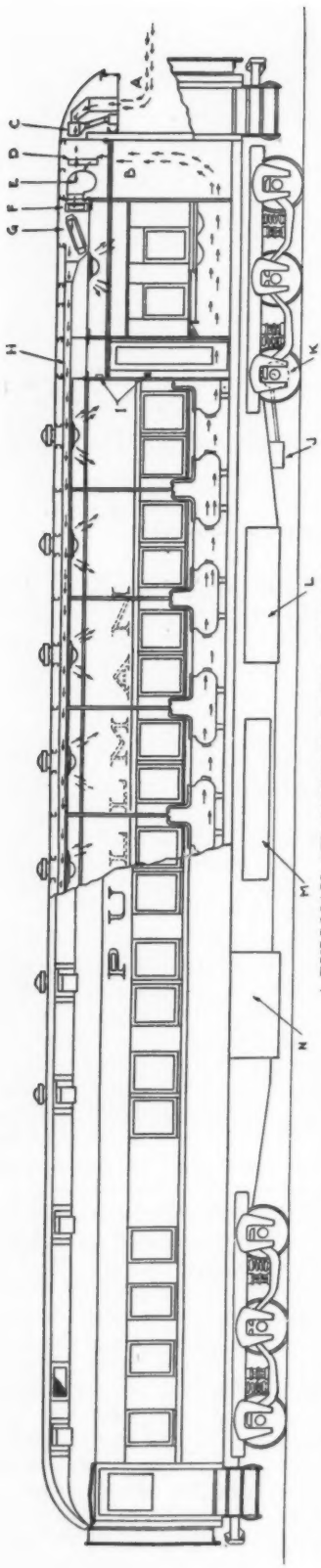
Divers working in rescue operations on the submarine *F-4*, which sank off Honolulu several years ago, reached the unprecedented depth of 275 feet in ordinary diving suits. This heroic work was slow and arduous, and the greatest care was necessary in the decompression of the men.

The first of the self-contained diving suits was developed by H. A. Fleuss about 50 years ago. Later he and R. H. Davis designed another suit providing air by means of regenerating drums. This was the first time that a diver had been entirely independent of a supply of air from the surface. A device on this early suit caused the air which had been breathed to pass through caustic soda, which took up the carbonic acid and thus purified it. In this suit a diver found it possible to reach a depth of 150 feet.

The most recent of diving chambers, for these devices are chambers rather than suits, are built of steel or of steel and aluminum. Some of them have huge, flexible joints and most of them carry their own independent air supply. Divers working in these chambers breathe air at normal atmospheric pressure, may be raised and lowered quickly, and suffer none of the ill effects produced by high pressures.

The divers now working to recover the $5,000,000 in gold which lies in the S. S. *Egypt*, sunk off the coast of France in 1922, are working regularly at a depth of 396 feet. Two types of diving chambers are being used in this undertaking, which is being carried out from the Italian salvage ship, *Artiglio II*. One is simply a steel observation shell fitted with heavy windows from which a diver may direct operations by telephone. The other is a huge metal chamber with jointed arms and legs. In this type the diver, operating steel pincers at the ends of the arms, can aid in the underwater work.

The descent to the S. S. *Egypt*, while the greatest for actual salvage operations, is not the furthermost depth to which man has descended into the sea. William Beebe, the undersea explorer, designed a steel sphere equipped with heavy glass windows in which he was lowered to a depth of 1,400 feet for the purpose of studying the fishes and flora of the South Atlantic. Beebe's sphere has been used regularly for observations and photography at depths of more than 400 feet. These recent developments but indicate the possibilities for future progress in exploration and salvage on the bed of the ocean. What has already been accomplished seems to open the way for still further improvements which will make it possible to do useful work in the unplumbed depths of which man has but a



A PULLMAN AIR-CONDITIONING SYSTEM

(A) Fresh air drawn in from outside. (B) Air from inside of car drawn into duct for conditioning. (C) Dirt collector for removing dirt from fresh air. (D) Filter for cleaning the air. (E) Fan. (F) Heating unit which is used in cold weather. (G) Cooled coils over which air passes and is cooled and conditioned. (H) Ducts through which cooled air passes. (I) Controls for automatically regulating the cooling, heating, and humidifying coils. (J) Generator supplying power to operate cooling system. (K) Positive direct drive for generator. (L) Refrigerator machine. (M) Brine tank from which cooled liquid is circulated to cooling coils. (N) Battery box for lighting system

superficial knowledge. Fulfillment of Jules Verne's vision of "20,000 Leagues Under the Sea" has already come within the compass of probability.

Train Comfort

LAST spring when the Baltimore and Ohio Railroad introduced the first completely air-conditioned train, the public's response was immediate and convincing. Executives of the railroad reported that passenger traffic on the air-cooled train (the *Columbian*, between Washington and Jersey City (New York) increased 600%.

The success of this venture points definitely to a widespread application of air-conditioning systems to railway passenger equipment. Besides the 46 cars equipped by the B. & O. last summer, five air-cooled dining cars have been placed in service by the Pennsylvania Railroad, and the Boston and Maine, experimenting with one day coach completed in September, found it so popular that parlor-car passengers forsook their Pullman chairs to crowd into the ice-cooled coach. The London and North Eastern Railway is apparently following suit, having announced the installation of combination heating and cooling systems on carriages for certain first-class trains, and at the Colonial Exposition in Paris this summer, the Paris-Orleans Railroad Company exhibited second-class car number B⁹y fi 5078 equipped with an air-cooling plant.

Although little has been said about it, the Pullman Company has also built air-conditioned cars, and they are now being tested in all parts of the country. Three systems are being tried by the company: (1) with mechanical refrigeration (similar to that used by the B. & O.); (2) with ice as the cooling agent (used by the B. & M.); (3) with a water-spray device. It has also begun experiments with a steam-jet system. In fact, the method of cooling cars by steam seems one of the most promising. The Carrier Engineering Corporation has demonstrated a steam-vacuum cooling method, and reports that the steam requirement for cooling the car in summer is considerably less than that needed in winter for heating. It is claimed, therefore, that the locomotive steam load is not increased.

It would be a difficult and dangerous thing, however, to discriminate with respect to these various systems at the present time. Each has its own vociferous protagonists, and doubtless each has its own peculiar advantages. It would seem reasonable, nevertheless, that those systems which can circulate warm, clean, conditioned air in winter as well as cool air in the summer will be the most practical because of their all-year-round usefulness.

The following temperature reductions reported for various cooled cars indicate the results obtained by the various systems:

	Outside temperature	*Temp. of non-cooled cars*	*Temp. when cooled*
Paris-Orleans Railway..	93.2° F.	95°	83.3°
Pullman *Jacksonville*...	104°	99°	82°

The B. & M. reported that conditions in its coach on September 9 and 10 were maintained at an inside temperature of 12° to 14° below the outside temperature and 14° to 19° cooler than conditions existing in other cars on the train.

The mere fact that it is feasible to supply a railway car with an air-conditioning plant is remarkable enough, especially when it is recalled how bulky and space-consuming such systems are in buildings. More remarkable still is the fact that light, compact systems are being designed which will operate so economically that they will add little to the cost of traveling. The art of air-conditioning is just coming into its own, and the next few years will see an enormous multiplication of its uses, not the least of which will be the widespread air-conditioning of residences.

A Glass Eye Sees New Horizons

INFRARED photography, which has made it possible for the camera to see and register images by light invisible to the eye, is literally extending the horizon in long-distance photography. Photographic plates sensitive to the long light waves in the infrared region of the spectrum were made as early as 1870, but modern research has developed dyes which open new opportunities in this branch of photography.

With the new infrared-sensitive plates it is now possible to photograph mountains and cities hundreds of miles away and entirely hidden from human vision by the blanket of haze which hangs above the earth. This atmospheric barrier, impenetrable to visible light waves, has only a slight effect on the penetration of the infrared waves. Astronomers welcome this new development in photography as an aid to the study of celestial bodies, and there is every indication that it will have important commercial applications.

Spurred to intensive research by the approach of an important astronomical event, Captain W. de W. Abney, an English army engineer, developed in 1870 a photographic emulsion that was sensitive to infrared light. It was made especially for the British astronomical expeditions which set out to witness the transit of Venus in 1874, and proved successful. Abney's formula, however, has never been reproduced, so far as known. The dyes now used in the infrared emulsions are of modern origin, and more efficient than those used by this earnest worker of 60 years ago. The excellence of Abney's emulsion is indicated, however, by the fact that the limits to which he extended the vision of the photographic plate were not again reached until 1926, when the dye neocyanin was found to be sensitive to light in the infrared region of the spectrum. The first major astronomical feat with color-sensitive plates was a map of the infrared region of the solar spectrum, made by Abney soon after he had worked out the formula of his emulsion.

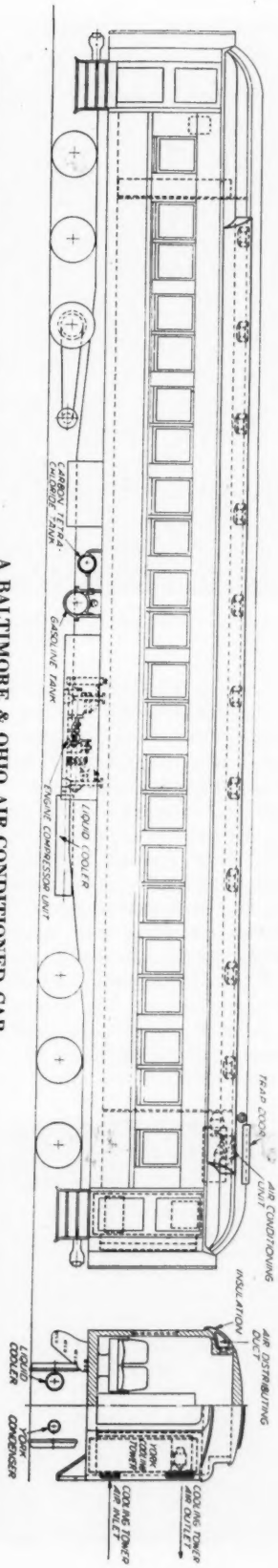
The recent developments in infrared photography concern emulsions which make possible photographs at very short exposures. Infrared sensitive plates requiring long exposures have been used by astronomers for some years to photograph the spectra of bright stars. The production of more sensitive plates is expected to make possible studies of stars which are either so far away or give off so little light that the old form of plate will not register them.

A decade ago photographs of the Yosemite Valley were made from Mt. Hamilton in California, a distance of 120 miles. The plates used in this experiment were sensitive to infrared rays which, however, were comparatively near the visible spectrum.

The most spectacular evidence of the possibilities in this field of photography are the photographs made by Captain A. W. Stevens, head of the photographic branch of the United States Army Air Corps. As early as 1929, Captain Stevens made a photograph of Mt. Ranier from an airplane 227 miles from the snow-capped peak (reproduced in The Review for January, 1930). This photograph was a "blind shot" because the eye of the observer could not penetrate the haze present in the atmosphere at all times. Captain Stevens made the photograph by compass bearing and the result was a clear-cut picture of the Cascade Range and Mt. Ranier.

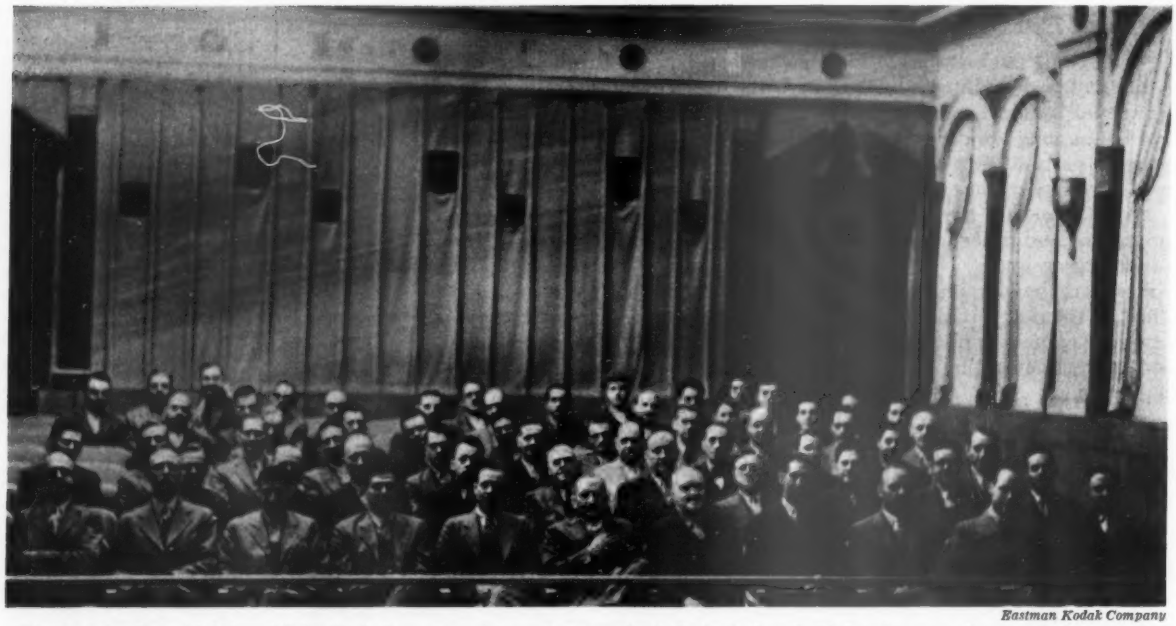
Since that time Captain Stevens has made a photograph in South America clearly showing the great Andean peak of Aconcagua at a distance of 310 miles from the camera's lens. In this remarkable photograph the line of haze over the pampas is curved, indicating the form of the earth, and it may be said that for photography of this type the only limit to the range of the camera is that fixed by the curvature of the earth. It would be quite possible on a clear day to make a photograph of the City of Detroit from an airplane flying at an altitude of 20,000 feet above Dayton, Ohio.

Infrared photographs are taken by placing a color filter over the lens so that the visible light, so necessary in other forms of photography, is entirely absorbed. Only the invisible waves of the infrared pass through the lens.



A BALTIMORE & OHIO AIR-CONDITIONED CAR

It will be noticed that the compressor is driven by a gasoline engine suspended beneath the car. It is estimated that the increased cost per passenger of air-conditioning amounts to approximately 20¢ per day. Application of air-conditioning equipment to trains presages its use on steamships—in fact the first-class dining room of the Matson liner MARIPOSA, *described on page 167, is air-conditioned. In a forthcoming issue of The Review the air-conditioning of residences will be treated at length*



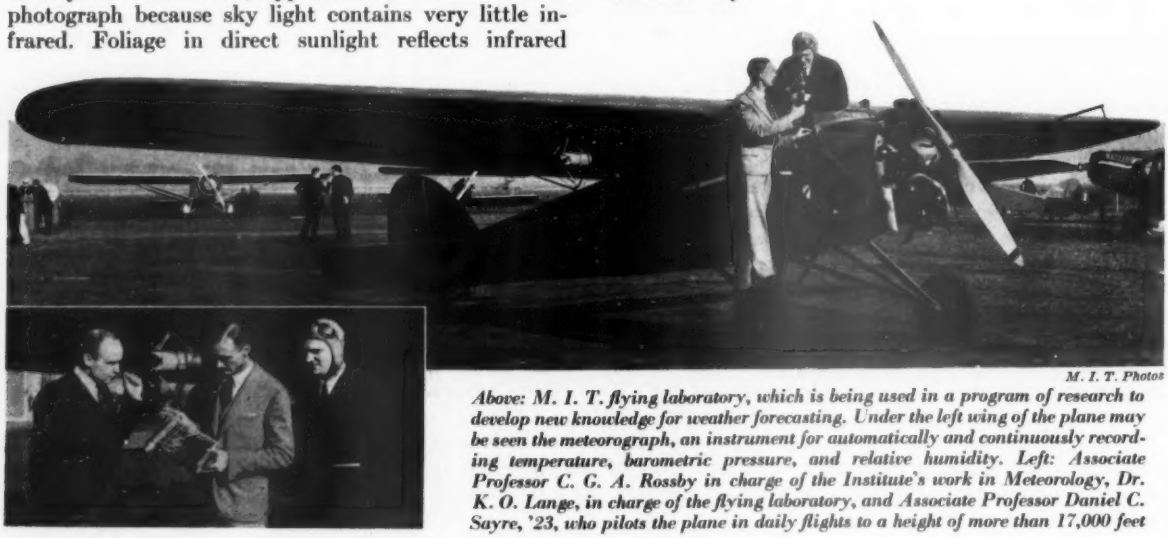
Eastman Kodak Company

Photograph taken with infrared light. To the human eye the room was completely dark. As described below the group photographed was made up of members of the National Research Council's tour of industrial laboratories

Recently Dr. C. E. K. Mees, Director of the Eastman Kodak Research Laboratory, demonstrated that it was possible to take a photograph in complete darkness. This was accomplished by placing 16, 1,000-watt electric lamps in a booth provided with a filter which permitted only the infrared light to pass. The special infrared sensitive plate used for this photograph was hypersensitized with ammonia and the exposure was one second. The group in this photograph included President Compton and Professor Dugald C. Jackson, Head of the Department of Electrical Engineering, who were members of the National Research Council's tour of laboratories.

Infrared photographs are of somewhat different appearance from the conventional picture. The sky, usually blue in nature, appears dark in the infrared photograph because sky light contains very little infrared. Foliage in direct sunlight reflects infrared strongly and therefore appears almost white, although detail is not necessarily lost. The reason that infrared light makes it possible to take photographs at great distances is that light of this wave length, which is much longer than the waves of visible light, is not easily scattered by haze or dust. Visible light, which is rich in blue, however, is quickly scattered by dust or moisture particles. This fact has already led to studies of the penetrating power of infrared light in heavy fog, a field which holds much promise.

As The Review goes to press an announcement comes from Dr. ("Eastman Kodak") Mees that photographic plates sensitive to ultraviolet light, at the other end of the spectrum from infrared, will shortly be made commercially.



M. I. T. Photos

Above: M. I. T. flying laboratory, which is being used in a program of research to develop new knowledge for weather forecasting. Under the left wing of the plane may be seen the meteorograph, an instrument for automatically and continuously recording temperature, barometric pressure, and relative humidity. Left: Associate Professor C. G. A. Rossby in charge of the Institute's work in Meteorology, Dr. K. O. Lange, in charge of the flying laboratory, and Associate Professor Daniel C. Sayre, '23, who pilots the plane in daily flights to a height of more than 17,000 feet

TRANSATLANTIC

The Alchemy of Prague

THE name of Prague, like the name of the city of Bagdad, had seemed to me to be the name of an almost legendary place of romance and mystery. The first building to catch the eye when we came out of the hotel was the great pile of stone with a four-cornered dome, which stands in a dominating position at the head of the principal street, *Vaclavski namesti*, and carries across its front in shining gilt letters the legend, Museum Regni Bohemiæ, the Museum of the Kingdom of Bohemia. So we were in Bohemia after all, the luscious vintage of Plzen further to prove it.

The capital of Czechoslovakia indeed proved to contain all of the fascinating things that are traditionally associated with it, but we found it also to be a modern city of nearly a million inhabitants, busy with its own affairs and with affairs which matter in the commerce of the world. Two professors of Charles University showed us the sights, professors respectively of chemistry and physics in a university which was founded in 1348. We were driven in an automobile of Czechoslovak manufacture, and we saw many similar cars in the streets. We saw a new large building, in the business section of the city, devoted entirely to Czechoslovak shoes. The owner of the building and manufacturer of the shoes hopes, we were informed, to make the whole world his market. He already supplies shoes to a large part of middle and eastern Europe, and offers serious competition to American manufacturers. The most expensive shoes sell for 100 crowns, or about three dollars.

Traffic signals shone near buildings which had stood for three or four centuries or longer, and Vaclavski namesti at night was as bright as Broadway with colored electric signs of neon, argon, and uranium gas.

We had seen in the New York Public Library the painting, by Vaclav Brožik, which represents Rudolf II, King of Bohemia, visiting the laboratory of his alchemist in the company of the ladies and gentlemen of the court, who constitute a group of interested spectators. The venerable alchemist, John Dee, is demonstrating an experiment while his assistant, Edward Kelley (with a broad-brimmed hat) stands behind his shoulder and wears an expression which suggests that he has deceived the credulous alchemist and, through the alchemist, the King. Rudolf was a great patron of alchemy and of other forms of magic and science. We, of course, wished to see the places which have figured in the tales about him. We were invited to the theater where, as it happened, we saw him on the stage in a play called "Golem," a satire on a recent novel which deals with the artificial man, Golem, which, or who, is supposed to have been created by the alchemist, Rabbi Levy.

John Dee came to Prague in 1583, a sort of ambassador extraordinary from the court of Queen Elizabeth. He was a learned and distinguished man, entitled to the respect of the King, and was no doubt given a laboratory within the castle itself. He was accompanied to Prague by Edward Kelley, who seems to have been a crook and adventurer, and who succeeded in convincing Dr. Dee that he possessed the secret of the transmutation of the metals. Dee returned to England in 1589, but Kelley died in Bohemia, for he was not successful in demonstrating his alchemical skill to the King. Count Rosenberg offered Kelley more money for his services than Rudolf had been paying him. Kelley left him but Rudolf captured and imprisoned him in the Castle of Krivoklat, about 40 kilometers from Prague near Plzen, under circumstances in which he had abundant leisure for the preparation of gold. Kelley died from injuries received while trying to escape.

Rudolf housed his less important alchemists in a row of little houses which still stand along Gold Alley behind the Castle at Prague. The old alchemical furnaces are now used for cook stoves. The land behind the houses slopes away precipitously to a deep moat. At the ends of the row of houses are towers, parts of the ancient fortifications, which are connected by a covered passageway running along the roofs. The tower which is nearer the Castle is the Hunger Tower, where tortures were inflicted.

The Czechoslovak Technical Museum, which is situated on the hill near the Castle, contains a fine reproduction of an old Bohemian alchemical laboratory. The exhibit was arranged by Zachar, a brewer of Plzen, who has made a hobby of Bohemian alchemy and has written several books on the subject.

An old Bohemian alchemical laboratory as reproduced in the Czechoslovak Technical Museum

In the play which we saw, Rudolf was supposed to have stolen Golem from Rabbi Levy, but he did not know the formula which would start the artificial man into action or which, if he were in action, would stop him again. Though the language was Czech, many of the incidents were very amusing. In one act the scene was in

the Hunger Tower and the alchemist was tortured by being hung up by his long beard. In the next act, he appeared with his beard trimmed to scarcely a handful. In another scene, the alchemist was barely visible on a darkened stage, tending his fire and muttering magic incantations. He summoned up spirits out of the blackness, for the chorus was dressed in black and invisible costumes which had evidently been streaked with fluorescent paint and the stage was suffused with invisible ultraviolet light, which developed the fluorescence of the designs, producing a weird effect.

Before leaving Prague we visited the old Jewish cemetery, where we paid our respects to the memory of Rabbi Levy. The cemetery has been in use from the Ninth to the Eighteenth Century, a strange place such as Doré might have pictured. Burials have been made five deep, but the stones which marked the earlier burials have been kept on top along with the later stones, and the whole place at present is so closely packed with standing stones that there is hardly foot room between them. Scrawny trees, 10 or 12 feet in height, and leafless at the time of our visit, grow in such space as they can find. A sarcophagus made of slabs of sandstone stands over the grave of Rabbi Levy, its top a sort of pitched roof made of two slabs and its front another slab standing higher than the rest of the structure. Through the space between the two slabs we saw what looked like scraps of waste paper, but were informed that messages to the spirit of the Rabbi had been written upon them. Pebbles had been placed on the top of the front stone in accordance with ancient custom. I added another, but was told that mine would have no efficacy because I had not brought it from America.

TENNEY L. DAVIS

English University Gossip

YOUR correspondent has stuck assiduously to his work at Cambridge University, like a good boy, and finds the appointed time for his letter coming around without any particularly thrilling incidents to report. The present document will, therefore, be devoted to gossip chopped pretty fine, in compensation for which next month's budget of news, gathered together during his peregrinations on the Continent, will be characterized by a plethora of undigested material.

Armistice day has come and gone, and the efforts of the undergraduates to collect money for disabled veterans took the form of a carnival that put me in mind of the late-lamented Technology Circus. After the vanguard of kilted poppy-sellers had extracted the first installment of our contributions at our own doorsteps, we proceeded into the city, to be met at the gate of each college by importunities for largesse in the form of pennies, to be placed in a row on the curbstone. Some of these rows were of surprising extent. There were also dart-throwing contests, fortune-telling booths, scales for weight-guessing, and all the features of the midway of a country fair. The Market Hill was the scene of a bull fight — synthetic — and around the square passed in solemn pomp the equipage of the King of Ruritania, escorted by a local militia armed with golf clubs. The grave of the dead nineties yielded up its ghost, and pre-Noachian motor cars vied with penny-farthing bicycles and five-passenger tandems. The sums realized were quite considerable, and I, for one, can testify to the centrifugal tendencies of the smaller coinage.

Littlewood's conversation class terminated the other day in a discussion of priority, author's responsibility, and the other personal sides of scientific activity. The question arose of the responsibilities of the author of a fellowship dissertation, written in good faith, and brilliant in execution, who discovers, subsequent to its submission, a ruinous blunder in an early stage of the work. Another matter that came up was that of the withdrawal from publication of a work independently conceived, but anticipated by a paper published after its conception. Here Landau seems to have the most austere code as far as he himself is concerned, and has suppressed papers already in proof. A third point raised was the possibility of concerted log-rolling by a mutual admiration society. It was claimed, I think with justice, that if three well-known mathematicians were to sponsor a hoax by founding a purely fraudulent branch of mathematics, with a logic of its own, they would referee one another's papers in the natural course of events, and the hoax would be completely successful.

Hardy and Littlewood are much struck by the highbrow mathematics used by the Bell Telephone people in the States. It was Campbell's table of Fourier transforms that started Hardy and Titchmarsh on their paper on Self-Reciprocal Functions. This served to renew interest in transformation theory in this country, and the January meeting of the London Mathematical Society is to be devoted to a discussion of the subject. Your correspondent is to open the discussion.

Americans are considerably in evidence about here. Carlitz is doing good work in number theory, our old friend, Watt H. Ingram, formerly of the M. I. T. Mathematics Department, is developing a new theory of electrical machinery, and Bissonette of Trinity College, Hartford, has had brilliant success with his investigations on the effect of light on the sexual cycle of birds and mammals. Millikan's son is working in zoölogy, and his father was here the other day to visit him. Littlewood was showing Carlitz and myself a difficult traverse at the base of one of the pillars in the cloisters under Trinity Library, and there we were standing in the gloom in various undignified attitudes, *sans* coats, when Millikan came along, asking his way to his son's quarters. We didn't know that he was on this side of the world.

I should have gone to Oxford to collect more material for this note, were it not for the fact that mathematical activity at Oxford is at present at a low ebb. With Hardy gone and Titchmarsh not yet arrived, almost all the analysis work is carried on by one man. Of course, Milne's astrophysical work is extremely interesting. He gave us a lecture here, and has developed a two-phase model of a star, that seems to find a niche for most of the observed sorts. G. I. Taylor seemed most enthusiastic.

Your correspondent has been pressed into duty for lectures on Generalized Harmonic Analysis next term, and will be able to report how a Cambridge class appears from across the lecturer's desk.

NORBERT WIENER

VISITING COMMITTEE REPORTS

On the Departments of Architecture and Hygiene

AT the request of the Executive Committee of the M. I. T. Corporation, The Review publishes as they are released the reports of the Visiting and Advisory Committees on the several departments of the Institute.

Visiting Committees, by way of explanation, are composed entirely of members of the Corporation itself, and it is their function to contribute to the understanding and coöperation existing between the Corporation and Faculty. Advisory Committees have as their membership not only Corporation members but leaders in technology and industry not otherwise connected with the Institute. These Advisory Committees affect a liaison between outside industry and the teaching and administrative staffs of the Institute.

Last month The Review presented a combined Visiting and Advisory Committee Report on the Department of Electrical Engineering. Below are presented two Visiting Committee Reports, the first on the Department of Architecture, the second on the Department of Hygiene and the Infirmary.

The Department of Architecture

WITH Professor Emerson absent for the entire year [1930–1931] from the school on his sabbatical, the Department has been in charge of Professor Harry W. Gardner, '94, who has handled the situation with good judgment and wisdom. No innovations or changes have been attempted on account of Professor Emerson's absence and the school has run quietly and satisfactorily.

The enrollment has continued about up to the limit that the staff and building can care for (about 270 students). It is interesting to note that the American Institute of Architects is agitating the question of fewer students in architectural schools, because at present too many are turned out to fill the vacancies in the profession. "Fewer and better students" is the plea of the profession.

To this we may answer that Technology has been caring for this matter by

(1) the stiffening of entrance requirements;

(2) the increase in tuition;

(3) lengthening the architectural course from four to five years;

(4) weeding out the poor students throughout the four years.

The number of outside prizes won by students during the last year is less than usual. The Boston Society of Architects prize was won by Frederic A. Pawley, '30, and an alumnus, Carney Goldberg, '28, was the winner of this year's Rotch prize (a European traveling scholarship).

Professor Emerson has now returned and is actively at work in the Department. Professor Carlu is on a three months' leave of absence and his place is to be taken by Professor Camelot of Paris. Professor Camelot comes highly recommended. He has been logist Prix de Rome and it is possible that this temporary change in Design heads may be of real value to the Department.

Respectfully submitted,

A. FARWELL BEMIS, '93
THOMAS C. DESMOND, '09
A. LAWRENCE LOWELL
HARRY J. CARLSON, '92, *Chairman.*

Hygiene and the Infirmary

IT IS interesting to note the increased use of this Department by the students, the Faculty, and the employees of the Institute. In 1928, approximately 19,000 patients were treated; in 1929, 24,000; in 1930, 28,118. This is partly due to the increase in numbers of students in the dormitories, but perhaps as much to the increased familiarity of all with the work of this Department. We cannot expect that this proportional increase will continue.

The annual examination of over 3,000 students is now taking place. Eight physicians are working at these physical examinations and entering those of underweight into a special nutrition class. This class had 33 members this last year and gained, on the average, almost six pounds per man.

Twenty-two men have received special investigations in regard to nose and throat. A number of students are suffering from troubles of heart, blood pressure, albumen, and colds, and here 181 men have had group lectures on their own particular trouble. These talks have been supplemented by personal conferences and examinations.

The Infirmary proper has been very busy at times during the year and particularly so during the heavy grippe period, when 26 beds were filled, using the emergency ward and the solarium, as well as all the main hospital rooms.

The Infirmary needs an additional room for the nurses' lockers, dressing, and toilet purposes; the space intended for this purpose has been taken by the Department of Biology.

A study has been made of conditions at the boathouse, and it will result in a more careful heart and kidney examination of intending rowers, as well as a check on all men before and after their daily exercise.

In general, the work of the Department of Hygiene and the Infirmary is carried on most effectively under the able guidance of Dr. George W. Morse.

Respectfully submitted,

WILLIAM R. KALES, '92
WILLIAM S. FORBES, '93
HARRY J. CARLSON, '92, *Chairman.*

THE INSTITUTE GAZETTE

Annual Alumni Dinner

"KEN thou ought of the Annual Dinner?" Like the maiden who was thrice demure as a cover for her eagerness, many shy alumni have gingerly broached this question, and now it can be answered.

The Annual Dinner of the Alumni Association is scheduled for the evening of Saturday, February 6, at 6:15. It is to be held as it was last year in the main ballroom of the Hotel Statler, Boston.

Preceding the dinner there will be a reception affording alumni and their guests an opportunity to meet the officials of the Institute. The reception and dinner is opened to women guests and wives as it was last year. The Committee on Assemblies, in fact, urges alumni and alumnae to come accompanied. There is to be a dance immediately following the dinner.

Among the items on the program will be an exhibition of interest to friends and alumni of the Institute, a speech by President Compton on the "Institute's Educational Policy," and another by Dr. Allan Winter Rowe, '01, on "Undergraduate Activities and Student Life."

Descriptive material as well as ticket applications will be sent shortly to all alumni within reach of Boston. Formal dress will be in order.

155th Alumni Council Meeting

TWO votes of major importance were taken at the Alumni Council meeting in Walker Memorial on November 30. The first of these was to accept the report of the Reorganization Committee which has been actively at work for a period of more than two years. The second was to instruct the Nominating Committee to submit this spring to the Alumni Electorate only three names to fill the three vacancies on the Institute's Corporation.

The report of the Reorganization Committee, after reviewing in great detail the results of the questionnaire sent to all former students of the Institute last summer, presented the following conclusions and recommendations:

"After due consideration of the results of these questionnaires, the earlier comments of individual alumni and alumni groups on the several committee reports which have been offered in the past few years, and with a careful analysis of the several factors which operated to bring this Committee into being and define the scope and character of its work, your Committee feels that certain conclusions are warranted.

"First, the earlier complaint of a disenfranchisement of the alumni group as a whole would seem to be an individual reaction rather than a true expression of opinion of the group of former students. In a matter touching their interests so nearly and offering them every opportunity to take over the full conduct of the affairs of the Alumni Association, but 8% of the total number and but 40% of the equivalent group usually replying on the annual ballot for officers of the Association and for Term Members of the Corporation have had the interest to put themselves on record. Those replying constitute but a small numerical fraction of the group who pay dues to the Alumni Association. *The question of a general nation-wide dissatisfaction would seem to be answered in terms that cannot be mistaken.*

"Second, the present system of electing men for nomination as Term Members to the Corporation is unsatisfactory to alumni and Corporation alike. The substitution of a three-candidate ticket to be formulated by a nominating committee which shall derive from the alumni body as a whole would seem to be definitely a method of choice thoroughly acceptable to the small number of alumni who have placed themselves on record in this connection. Your Committee feels certain that the nomination of three rather than nine candidates is, for many reasons which need not be canvassed here as they are familiar to all, the course which is preferable. Equally, your Committee is mindful of the potential difficulties of organizing a nominating committee which shall be elected by sectional groups of the entire alumni body. The disappointing and non-representative character of the response to this questionnaire raises the grave question as to how far a nominating committee deriving from general suffrage is to be regarded as more representative than is the present nominating committee which derives in part, at least, from directly elected representatives of every class in the Institute and in smaller part by the directly appointed representatives of the several local clubs. As, however, the present method of composing the nominating committee has been a principal basis for the hostile criticism offered to the existing system, it seems wise to your Committee to make an effort to embody the general idea of a national nominating committee to carry out the important function of providing Term Members for the Corporation. To avoid any final commitment until the plan has had adequate trial, your Committee con-

siders the formulation of a tentative plan which can be put into force for a limited stated term of years which can then be evaluated on the basis of actual performance for final confirmation or discontinuance.

"Third, inasmuch as the appointment of an Alumni Director is disapproved by the Corporation and is a question upon which the alumni body would seem to be nearly equally divided but with a slight dominance of approval of the present system, your Committee feels that the appointment of an Alumni Director may suitably be dropped from further consideration and the present method of operation confirmed.

"Fourth, the policy of conduct of The Technology Review would seem to be the one question upon which an overwhelming majority of the alumni are in hearty accord. That this should be so is not surprising in view of the outstanding record made by this journal during its more recent years of operation.

"Fifth, your Committee considers the plan whereby the alumni body be constituted of (a) full members, to be designated as 'Members,' who are either graduates of M. I. T. or such non-graduates as shall be elected to membership as at present, and (b) associate members who shall be those students such as those of the earlier Army and Navy schools or similar groups who shall be elected to such a degree of affiliation under conditions which shall be established and incorporated in the working instrument of the Association.

"Sixth, inasmuch as the continuance or disbandment of the Technology Clubs Associated is a matter of primary concern only to the local club in its association with other local clubs, your Committee feels that this is a matter which can be properly and appropriately settled only by the action of the body in question itself. It would call attention to the fact, however, that the discontinuance of The Technology Clubs Associated will increase very materially the difficulties of operation of the composition of a nominating committee through the suffrage either of the entire group of former students or of the Alumni Association."

SUMMARY

"Your Committee recommends:

1. That that portion of the Constitution dealing with the election of candidates for nomination as Term Members of the Corporation to that body be suspended for a limited term of years, the exact number to be decided on subsequently, and

2. That a plan be devised which will permit of the election of candidates for Term Membership by a nominating committee which itself shall be elected on a geographical or similar basis by the Alumni Association operating as a whole or in sectional groups.

3. Further, that this nominating committee shall conduct its work largely or entirely by correspondence and in camera and that it shall have final power to present the names of three candidates and three only to the Corporation for the action of that body.

4. That the Association continue to function with an Alumni Secretary who shall attend to routine matters and correspondence as at present, and

5. That consideration shall be given to an expansion of the program now in force whereby a variety of speakers shall be sent to local clubs to present to the members of the latter matters pertaining to the Institute of interest to them.

6. That the Alumni Association consist of two grades; namely, 'Members' who shall be either graduates, who attain this status automatically on graduation, or former students who shall be elected under substantially the conditions which obtain at present, and 'Associate Members' who shall be elected from the group of former students at the earlier Army and Navy schools or similar groups which at some future time may come into being.

"Your Committee presents this material for your discussion, consideration, and action. In order to facilitate the latter it recommends, finally:

7. That a Committee with power be appointed by the President to realize such portions of this report as require changes or suspensions in the existing constitution and by-laws of the Alumni Association and to formulate plans embodying such other recommendations as do not affect immediately and directly these working instruments."

In accepting this report the Council at the same time voted that the President be empowered to appoint a committee to put the report's recommendations into effect. This the President did and included on this Constitutional Committee Allan W. Rowe, '01, Harold B. Richmond, '14, Donald G. Robbins, '07, Francis J. Chesterman, '05, Francis E. Stern, '16, and Samuel C. Prescott, '94, as chairman.

Despite the weighty consideration that it necessarily gave to this report, the Council meeting had its lighter moments. Charles W. Aiken, '91, recently returned from Australia, was required to pinch hit as a salad orator and he dwelt at length on a marvelous insect (or maybe it is a worm) that is found in the southern hemisphere (of Aiken's brain). This animal lives in a cellophane cell that is suspended from the branches of trees and is equipped with electric headlights. Hanging from it are fish lines on which are placed at intervals attractive drops of nectar to serve as bait for the insect's prey. Mr. Aiken also told of the eating customs which had come to his notice and described a very ingenius knife which could be used either as a split knife for eating whole peas or as a whole knife for eating split peas. A safety combination spoon was another interesting tool which he found. This had a filtering arrangement enabling it to distinguish between various kinds of soup.

The Secretary reported that Robert C. Ashworth, Jr., '25, had been elected the new representative of the Fall River Club and that D. L. Rhind, Assistant Bursar of the Institute, had been made a regular guest.

After Mr. Ashworth's presentation at the Council, Samuel C. Prescott, '94, presented resolutions on the death of Dr. Stratton, and C. Frank Allen, '72, on the death of Howard A. Carson, '69.

Institute's Property on Boylston Street

ROGERS Building on Boylston Street, the center of the old Institute in Boston, is now the headquarters of the Department of Architecture, while the

Walker Building on the western side of Rogers is now being used by Boston University although it is still owned by the Institute.

The land on which both of these buildings stand was granted to the Institute by the Commonwealth of Massachusetts in 1861. The grant specified certain restrictions. Everett Morss, '85, Treasurer of the Institute, has had the legal firm of Rackemann, Sawyer and Brewster prepare a report on the acts and resolves of the general court relating to the M. I. T. and on the title and restrictions of the Boylston Street Property. Below are presented excerpts from the latter report:

"The Commonwealth of Massachusetts, by chapter 183 of the Acts of 1861, granted to the Institute the westerly two-thirds of the square in Boston bounded by Berkeley, Boylston, Clarendon, and Newbury Streets, subject to the restrictions that not more than one-third of the land should be built upon and that the land should never be sold but should be kept as an open space or used by the Institute for its educational purposes. The easterly one-third of the square was at the same time granted to the Boston Society of Natural History.

"The rights of the Commonwealth to enforce these restrictions were released by chapter 438 of the Acts of 1903, but the release was subject to the rights of other persons, and subject to new restrictions that buildings should be set back certain distances and that the land should never be used for a stable or for mechanical or manufacturing purposes.

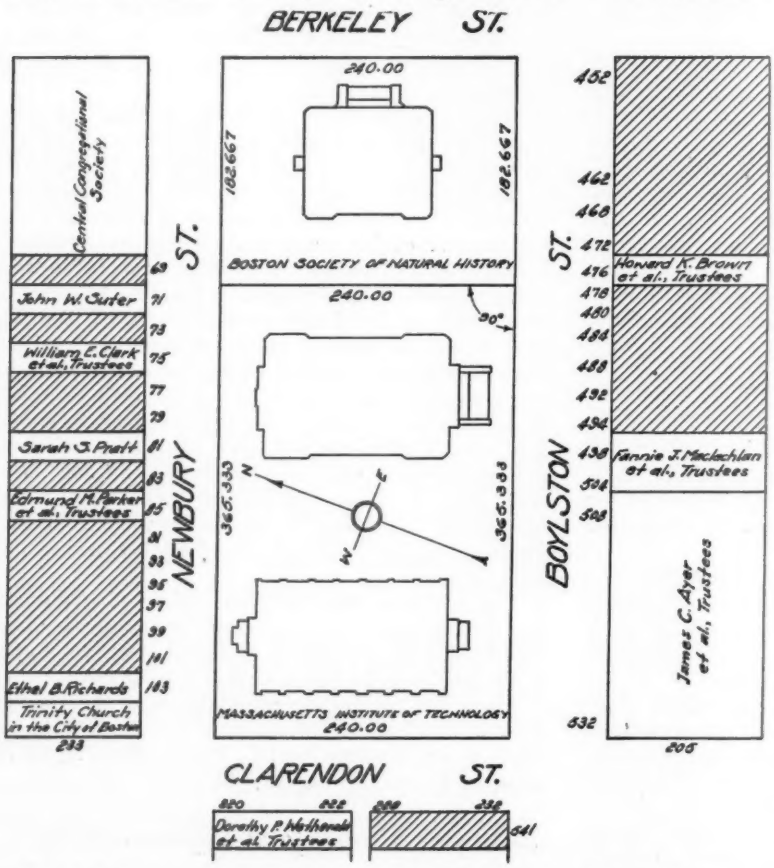
"These restrictions have been passed on by the Supreme Judicial Court three times.

"In the first case, Wilson v. Massachusetts Institute of Technology, 188 Mass. 565, decided in 1905, the court held that the Act of 1861 operated to create in the owners of abutting land equitable rights to enforce the restrictions imposed by the Act, which rights were not affected by the Act of 1903, and granted an injunction against the erection of buildings covering more than one-third of the land.

"In the second case, Boston Society of Natural History v. Massachusetts Institute of Technology, decided without opinion on January 1, 1906, the Court held that the Act of 1861 created no restrictions in favor of the Natural History Society.

"In the third case, Massachusetts Institute of Technology v. Boston Society of Natural History, 218 Mass. 189, decided in 1914, the Court held that the restriction against the sale or transfer of the property had been abrogated to the extent that the bare legal title could be sold or transferred, but only subject to the restrictions, imposed by the original Act, that the land must be kept open as an open space or used for the educational purposes of the Institute; that there was no restriction on the Institute's right to change the locations of its buildings, provided the other restrictions were not violated; that if the circumstances of the neighborhood were to so change that the restrictions ought not to be specifically enforced, they would, nevertheless, still remain in existence as a subject of pecuniary compensation, and that the only properties entitled to enforce the restrictions imposed by the original Act, so far as they remained in force, were the lots abutting on Boylston, Clarendon, and Newbury Streets and facing the square, that is, only the lots on the south side of Boylston Street and the north side of Newbury Street, between Berkeley and Clarendon Streets, and the lots on the west side of Clarendon Street between Boylston and Newbury Streets.

"The case last mentioned was based on petitions to the Land Court brought by the Institute for registration of its title and for a determination of the validity, nature, and extent of the restrictions, and decrees were finally entered in the Land Court in accordance with the rules laid down in this case. Title was registered subject also to the provisions of certain instruments signed by the Institute in (*Concluded on page 190*)



The Boylston Street (Boston) property of the Institute and its environs. The cross-hatched lots on the plan have released the Institute from the restrictions described in the adjacent report. The remaining lots had not released as of August 31, 1931

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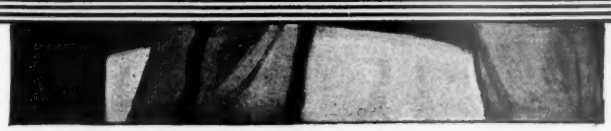

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LUXURY AFLOAT

(*Concluded from page 165*)

and Marine Engineers. Since passenger traffic is so seasonal, as Mr. Peterson pointed out, there "are very few trips a year when the 900- and 1,000-footers will approach capacity in passenger-carrying performances, and during the remainder of the year these vessels will not carry any more passengers than, say, the 600- or 700-footers. . . ."

Mr. Peterson's estimates as to the expected annual return on the capital invested are illuminating. A 500-foot liner, operated at about 17 knots sea speed, might reasonably be expected to yield about 5½%; a 600-footer at 18¼ knots, 7%; a 700-footer at nearly 20 knots, slightly better than 3%; an 800-footer at 21¼ knots, slightly better than 1%. His reckonings showed that 900- and 1,000-footers, even if operated at under 24 knots, would show losses in the neighborhood of 3½% and 8½%, respectively.

From what has been set forth above, it must not be construed that world shipbuilding is booming. On the contrary, while Lloyd's reported that for fiscal 1931 (as of June 30) tonnage added during the year was about 97% of fiscal 1930, the tonnage of plans passed for new vessels during 1930–31 totaled but 27% of that approved during 1929–30. The gross tonnage of all vessels afloat on June 30, 1931, was about 70 millions, an increase of 21 millions over the corresponding figure for 1914. Of the 70 millions, 10½ millions were laid up, or double the amount laid up on June 30, 1930. In addition to the 10½ millions laid up, almost a million tons were broken up for scrap during the year.

Two striking factors are to be noted in considering the 557 vessels of 1,758,610 tons added during 1930–31:

(1) Of 797,771 tons, 128 were tankers for carrying oil in bulk. These bring world tanker tonnage to over 8½ millions compared with five in 1922 and less than 1½ in 1914.

(2) Of the new tonnage, 223 vessels, comprising 69%, were fitted with internal combustion engines. This made a total world inventory of 4,080 motor ships compared with 1,620 in 1922 and 297 in 1914. Motorship tonnage now totals nearly 9½ millions compared with 1½ in 1922, and less than a quarter million in 1914. Of the 223 new motor ships, five use the diesel-electric drive, the largest being the *Permian* of 8,955 tons.

The post-War trend in types of engines and fuel for all world tonnage, including vessels of 100 tons and upwards, is shown below:

Types of Engines	*1922*	*1931*
Steam reciprocating	84.3%	73.1%
Steam turbines	13.2%	13.2%
Motors	2.5%	13.7%
	100.0%	100.0%
Fuel		
Coal	73.9%	57.2%
Oil	26.1%	42.8%
	100.0%	100.0%

THE FUTURE OF ENGINEERING

(*Concluded from page 164*)

and no one, least of all the engineer himself, knows what surprises he may have in store."

Back of the statement is the idea, based on experience, that applied science is now the most potent factor in shaping our civilization. On it depend our means of communication, exchange of ideas and of goods, our modern houses and physical environment, our sanitation and agencies for public health, our modern methods of production. A single scientific discovery or invention, like the printing press, the electric generator, the radio tube, the automobile, may largely transform our methods of living.

But consider for a moment the significance of such developments. While these factors add to our comfort, interest, and enjoyment of life, their chief importance lies in the fact that they create opportunities for better living. Let me illustrate what I mean.

DOES this technological age bring greater human happiness than, for example, the Periclean Age of the ancient Greeks? Now, man's enjoyment of Periclean Greece would depend on his political status, on whether he was a member of the small, aristocratic class that had leisure and freedom for thought, based upon the productive power of thousands of human slaves, or whether he was one of those slaves. But in this day and generation, machinery is the slave of all men, and to an unprecedented extent all men may have opportunities for education, recreation, and the nobler things of life, because machinery is doing most of the drudgery for them. If men had to supply the energy that America uses from water power, coal, and gasoline, we should need the exhausting labor of five thousand million slaves! Such is the debt of modern man to technology. *Applied science is not an end in itself, but it* is *the most powerful means ever discovered for supplying the opportunity to secure the finest things of life.*

But there is one other implication in Professor Shotwell's statement. If "the pathway to the future is in the hands of the engineer," then he has a very grave responsibility! It is not enough that he should supply technical service or produce new implements for man's needs or desires; he must take a leading part in seeing to it that the new world which he is creating is a good sort of a place in which to live. He must realize the social responsibilities of his profession. Whether he is a practicing engineer, a research worker, a teacher, an architect, or a business man, his position of leadership in the economic life of the country carries with it the responsibility to take a leading part in meeting its social problems. Questions of conditions of labor, responsibility for workmen's employment, pension, suitable wage, and so on; questions of use of public funds (which exist largely because of the engineer); questions of public support of education and of research (since funds and time for them exist largely because of the engineer); questions of international policy (since he is largely responsible for international contact and communication) — all these questions must be advantageously handled, else the power of the engineer will have rendered an ill service to mankind.

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INDUSTRIAL DISEQUILIBRIUM

(*Continued from page 170*)

Workers become specialized to certain tasks, men and women take root in certain regions, money is invested in relatively permanent forms — these and other factors tend to reduce the mobility of labor and capital. It may take a long time to decrease the productive capacity of industries that are highly conservative and inflexible. Agriculture is one of them.

During the War the scarcity of basic commodities and the consequent high prices called forth an unprecedented output from the agricultural industry, especially in North and South America. When the War ended the industry failed to adapt itself to the new conditions. The markets for wheat, sugar, coffee, textile materials, and other staples became congested. Prices fell and this affected the ability of farmers everywhere to buy manufactured goods. So the effects of agricultural depression were communicated beyond the localities where the staple industries were situated to the chief manufacturing nations of the world. This is only one example of the manner in which one branch of production may get out of line with others because of a lack of ready response to market tendencies.

Some keen students of business insist that competition itself is a source of disturbance. They assert that producers, straining for larger profits, embark upon programs of expansion in the hope of realizing the economies of mass output, and upset the balance of demand and supply by overestimating the proportion of the total demand which their competitors will allow them to secure. This is another instance of imperfect market foresight and is undoubtedly an important cause of maladjustment. But perhaps even more unsettling are the attempts to avoid the results of cutthroat competition by some method of price control that leaves production unchecked. This kind of device is generally worse than useless, for, by holding out the hope of higher prices or deferring the arrival of a fall in price, it tends to stimulate output and aggravate the distress. When the price control collapses the situation is much worse than it otherwise would have been. The experiment of Great Britain with rubber, of Brazil with coffee, and similar schemes of other countries nearer home have demonstrated the harmfulness of this type of interference with the free play of economic forces.

As soon as the system of prices loses its elasticity, derangements are almost certain to occur. As was indicated above, price movements have an important part to play in the maintenance of industrial equilibrium. By sinking below a profitable level, they warn us that it is time to curtail production; by rising above that point, they signal the desirability of expansion. If not permitted to move, they fail in the proper performance of these functions. Professor Arthur B. Adams points out that "large business enterprises, particularly in the fields of mining, manufacturing, and trade, through monopolies, cartels, and trade associations have been able in great measure to hold the prices of their products at stable points in the face of an increasing output. The farmers, on the other hand, partly because of the lack of joint ability to control out- (*Concluded on page 188*)

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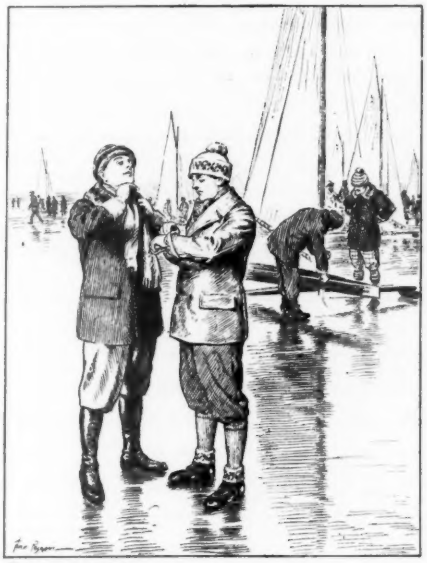

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INDUSTRIAL DISEQUILIBRIUM

(*Concluded from page 186*)

put and the marketing of their products, have little power to hold up the prices of their products. Producers' control of the prices of one class of products and the lack of control by the producers of another class of products have thrown the price system out of adjustment and have caused an unbalanced development of industry."

Much of the economic legislation generated by the intense nationalistic feeling which developed during and after the War has been of a restrictive nature tending to throw the international industrial machine out of gear. Take sugar, for example. Japan, Italy, and other countries, formerly importers of this article, contrived, through import restrictions, to become much more nearly self-sufficing than they had previously been, with the result that there was a congestion of supplies in the open market. It is essential to the stability of world economy that each nation should adopt considerate policies in their commercial intercourse with others, especially if this intercourse is of long standing. After business has become adjusted to established tariffs and other political restrictions, changes in this legal framework may throw into disorder the whole complex system of international trade relations.

Perhaps enough has been written to indicate the type of disturbance that is constantly threatening to interrupt the orderly progress of business. The severity of the present depressed condition of industry is due to the simultaneous operation of these and other less important causes of derangement. To persons of a radical turn of mind, they may suggest the necessity for revolutionary changes of a socialistic nature, such as the abolition of competition and the substitution of social control after the manner of the U. S. S. R. But in the minds of the more conservative, an understanding of the underlying tendencies to maladjustment is more likely to evoke some practical ideas for the strengthening of our economic system against the recurrence of another period of stagnation.

THE HUMAN POWER PLANT

(*Concluded from page 162*)

but it is not the last word in this type of apparatus by any means. Certainly much more sensitive instruments, with wider frequency response, are needed for research into detail. Much is yet to be learned of the underlying causes of the phenomenon which is studied broadly in electrocardiography and the like. Instruments which will produce accurate records of the potential differences appearing in single cells, in nerve fibers and so on, may well lead to much of interest and value, and the work is proceeding intensely in many research laboratories of medicine, biology, and physiology. The physicist and the electrical engineer can coöperate best in this research by the supplying of tools and the analysis of the strictly physical aspects of the extremely complex phenomena involved.

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INSTITUTE GAZETTE

(*Concluded from page 182*)

connection with a Hyatt light and an area in the sidewalk, and a steam pipe to other property of the Institute.

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"The situation as it exists today can be visualized from the plan on page 182 which shows all the properties originally entitled to enforce the restrictions. Lots cross-hatched on the plan have released; and remaining lots had not released up to August 31, 1931."

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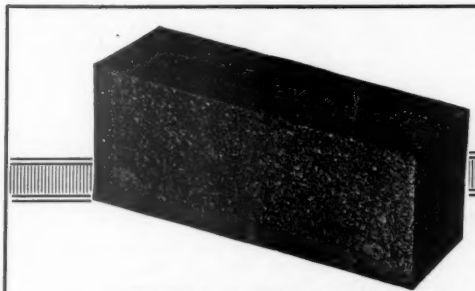

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THE TABULAR VIEW

CITY planning in America has undergone a curious inversion. In the early days most of our cities were laid out by civil engineers, of whom L'Enfant was a notable example. At the present time, a majority of our city planners have received their basic training as building architects or landscape architects, mostly the latter. Engineers have worked on single aspects of municipal planning problems, but few of them have been responsible for integrated regional planning. ¶ In Germany the history of city planning has been exactly the reverse, and now the civil engineer is the most important figure in regional planning there. It may be noted, by way of parenthesis, that there is an indication that the American civil engineer is looking toward a more active participation in this field. The Department of Civil Engineering here at the Institute, for example, is interested in the planning of airports, an activity that is now paradoxically in the hands of the architect and landscape architect. ¶ ROMAN F. HEILIGENTHAL, the author of the article on German city planning on page 199, symbolizes in his person the state of affairs in Germany. He is one of the foremost city planners in that country, although by profession he is a civil engineer. He is chairman of the Department of Civil Engineering at the Technical University at Karlsruhe, and holds doctorates in both engineering and economics. In his capacity of city planner, he teaches the subjects of city planning and city engineering, is a member of the German Academy of Town Planning, the American Civic Association, the International Federation for Housing and Town Planning, consultant for the cities of Berlin, Essen, Düsseldorf, Breslau, Wetzlar, Rostock, and he was formerly town planning official for the city of Berlin. In addition to all these activities, he has published various treatises on city planning; notably, *Deutscher Städtebau* (1921), *Berliner Städtebaustudien* (1926), and *Städtebaurecht und Städtebau* (1929). It is obvious that Dr. Heiligenthal speaks with great authority, and his doctrine that the engineer should play a prominent part in city planning will doubtless fall on fertile ground in America. ¶ His article was translated from the German by HUNTER ROUSE, '29, who recently returned to this country after holding an M. I. T. Traveling Fellowship in Hydraulics. He will be remembered as the author of an article entitled "Amerikanismus" in the December, 1930, Review. Another article by him on one of the great German hydraulic laboratories is to appear in a forthcoming issue, as well as two other translations of articles by notable German engineers on the social importance of their profession in the Fatherland.

TWO articles in this issue are contributed by Dr. NORBERT WIENER, a contributing editor of The Review, who is now lecturing at Cambridge University, England, and in his spare time visiting and traveling on the Continent. His article on page 201 throws a new and

(*Concluded on page 195*)

THE TABULAR VIEW

(*Concluded from page 194*)

revealing light on the mysteries of modern physics, while his monthly letter from abroad (page 218) records his impressions of conditions among the intellectual classes in Europe under the trying conditions of unrest and uncertainty that now prevail. ¶ Gottfried Wilhelm Leibniz, who evolved some astonishingly modern physical concepts as Dr. Wiener points out in his main article, is growing in stature as a scientist, although dead more than 200 years. Last month The Review, in describing the differential analyzer developed by Dr. Vannevar Bush, '16, noted that Leibniz was probably the first to visualize the usefulness of machine computation. In a notable paper on the differential analyzer which Dr. Bush published in the *Journal* of the Franklin Institute, he paid tribute to the foresight and brilliance of this great German philosopher, scientist, and mathematician. ¶ Last month The Review began with an article by Dr. Ralph E. Freeman a series of papers on current economic and business problems. The series is continued in this issue with five papers prepared by members of the Institute's Department of Economics and Statistics, and of Business and Engineering Administration. As explained in the editorial note at the beginning of this group of papers, they were originally presented at a conference held for graduates of the latter named department. Next month, there will be another full length article by Robert F. Elder, Professor of Marketing at the Institute. The Review wishes to express its appreciation to the aforementioned departments at the Institute for making these studies of economic and business conditions available for publication. It is the wish of both The Review and these departments that they will contribute to an understanding of the "economic disease from which we are suffering" and may suggest curative procedures. ¶ Registrar JOSEPH C. MACKINNON, '13, author of the article on electrical engineering graduate instruction, joined the Institute staff as assistant in physics in 1915, after having spent the two years following his graduation in engineering work. In 1918 he became an instructor in physics, and in 1921 a member of the Faculty. He has been Registrar of the Institute since 1923.

AS a result of the last football season, there has been widespread discussion of college athletics and their effect upon the health of the participants. Most of this discussion has been cursory and uninformed and there is the need for a thorough and impartial investigation of the facts. The article on page 209, happily, fills this need. It is a thoroughgoing study, from the point of view of the physician, of the medical literature on the subject of athletics and health. Its author, Dr. ALLAN W. ROWE, '01, hardly needs an introduction. As director of the Evans Memorial of the Massachusetts Memorial Hospitals, and as Secretary of the Institute's Alumni Advisory Council on Athletics, he is thoroughly informed on every phase of the problem.

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